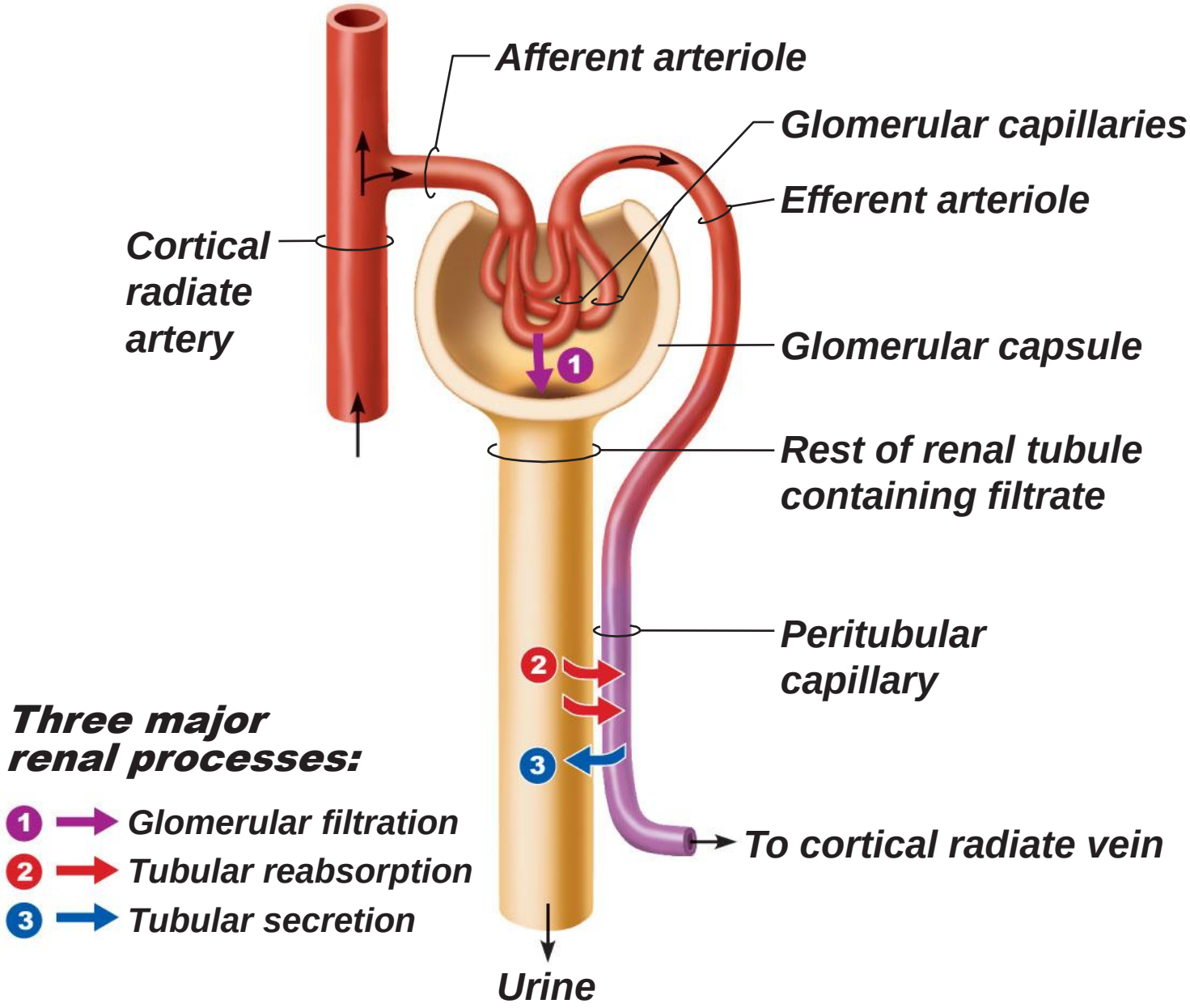
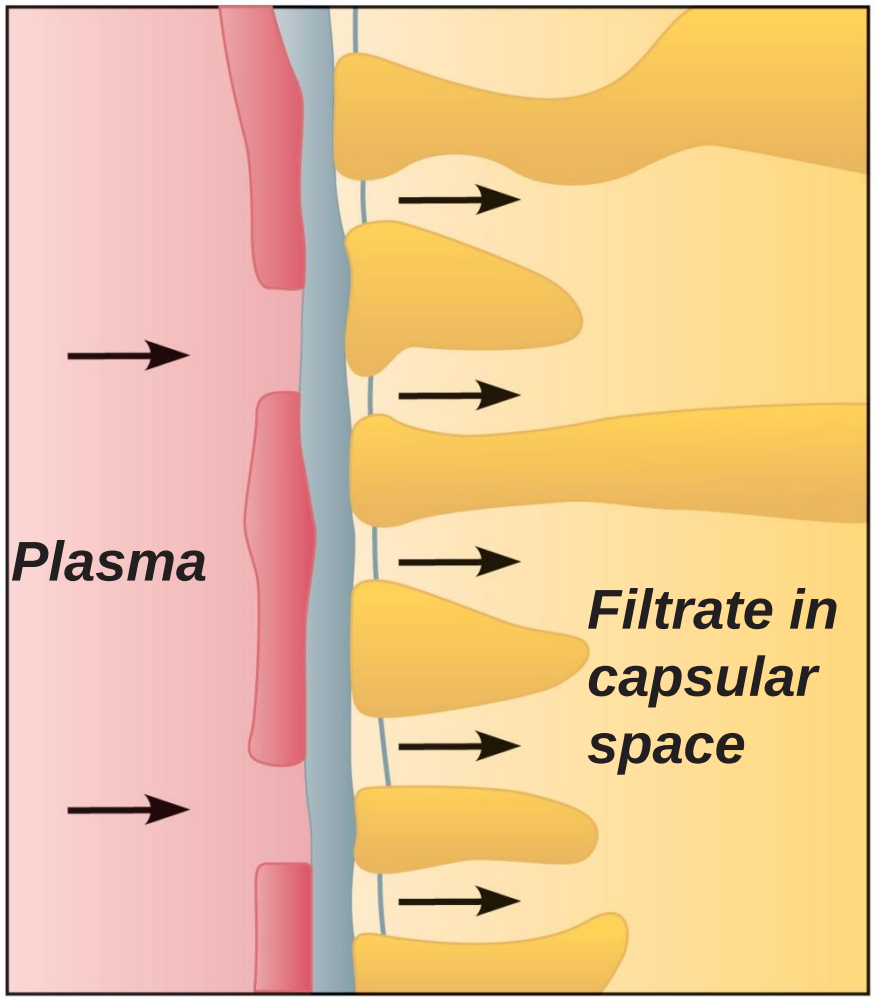
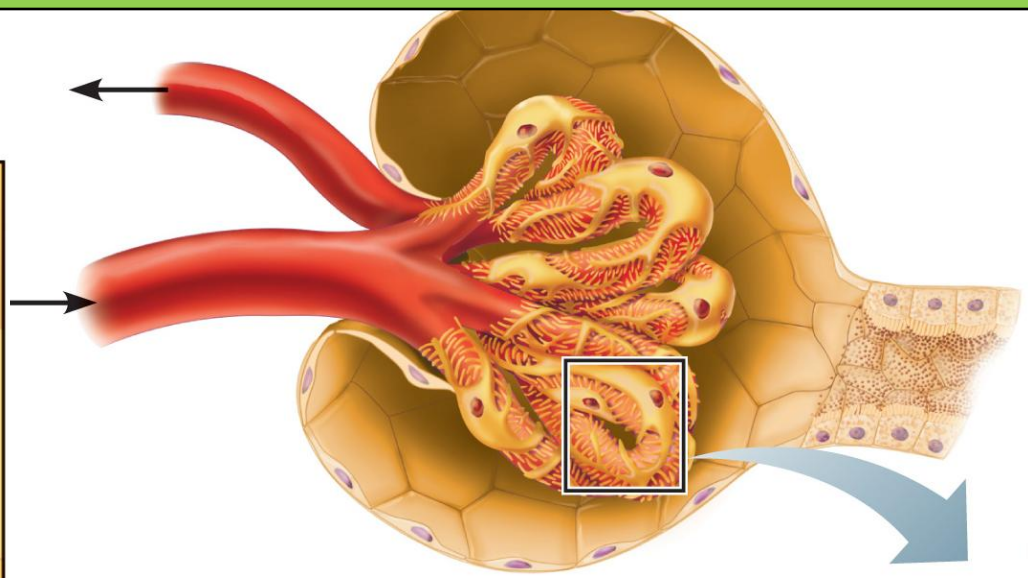
# 3 Steps of Urine Formation

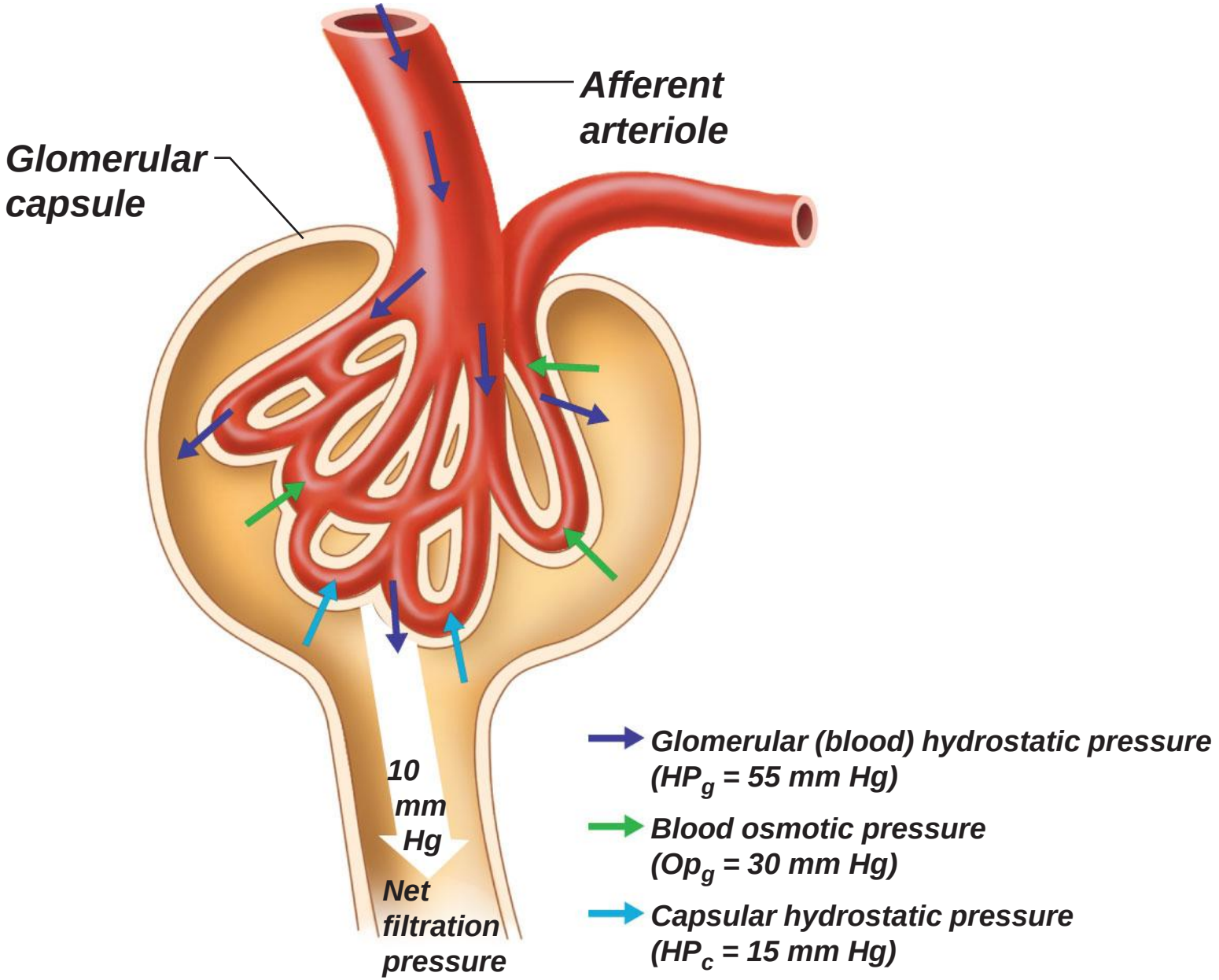


# Filtration Membrane



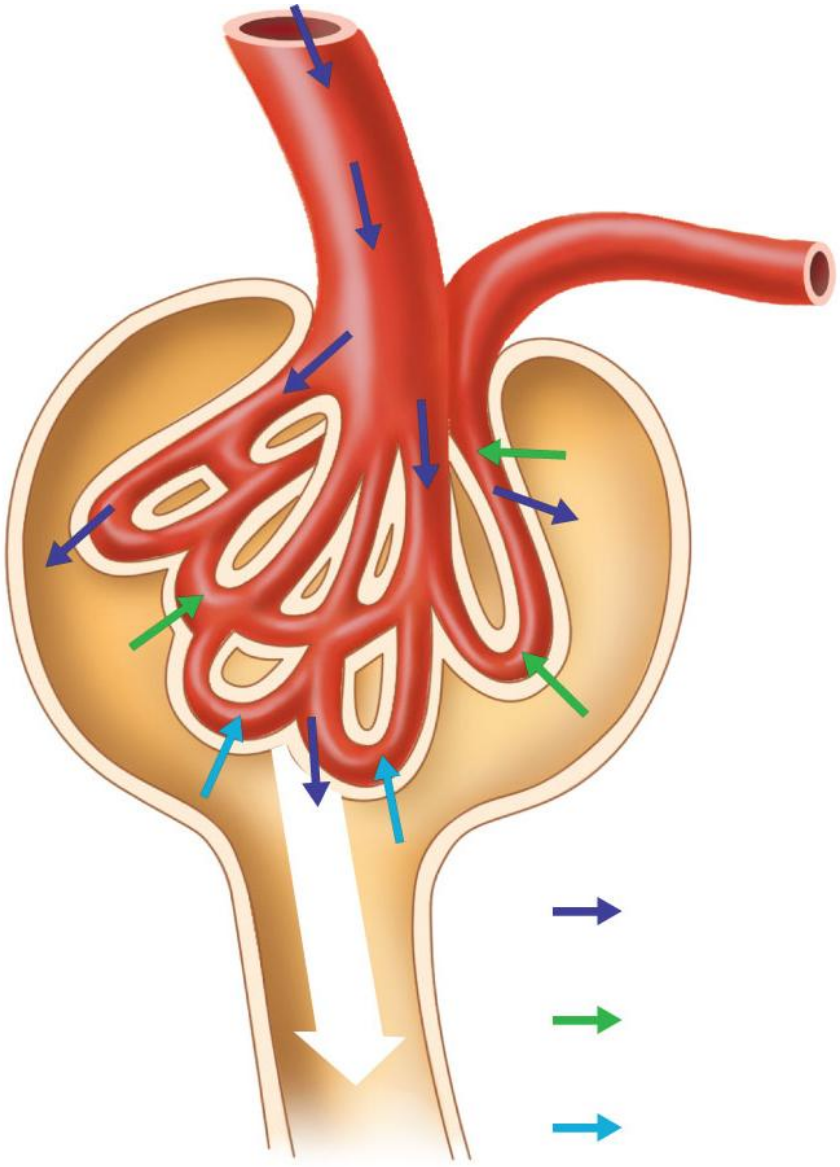



# Filtration Pressure

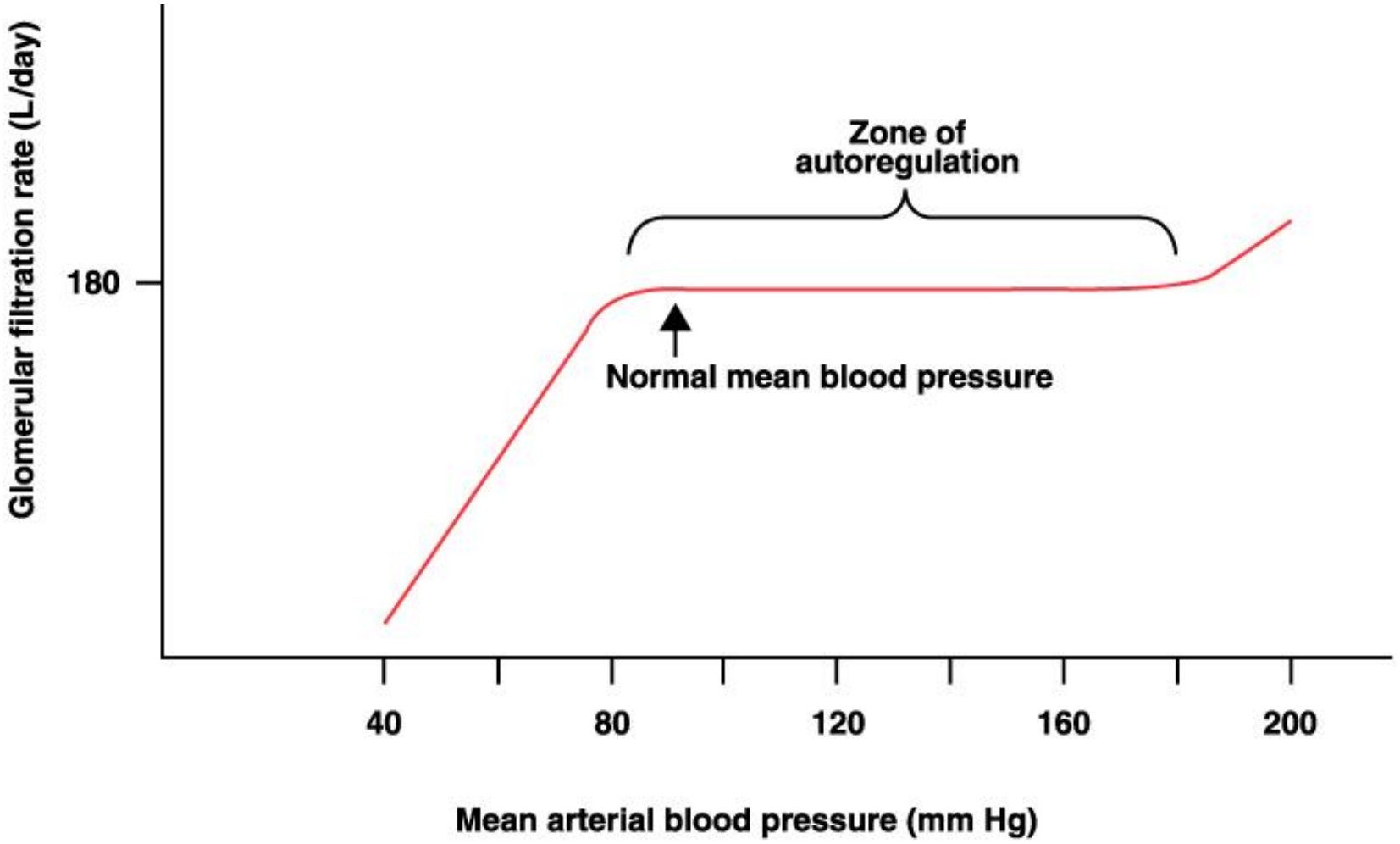

Afferent arteriole
Glomerular capsule
10 mm Hg
Net filtration pressure
Glomerular (blood) hydrostatic pressure ($HP_g$ = 55 mm Hg)
Blood osmotic pressure ($Op_g$ = 30 mm Hg)
Capsular hydrostatic pressure ($HP_c$ = 15 mm Hg)

# Glomerular Filtration Rate (ml/min)

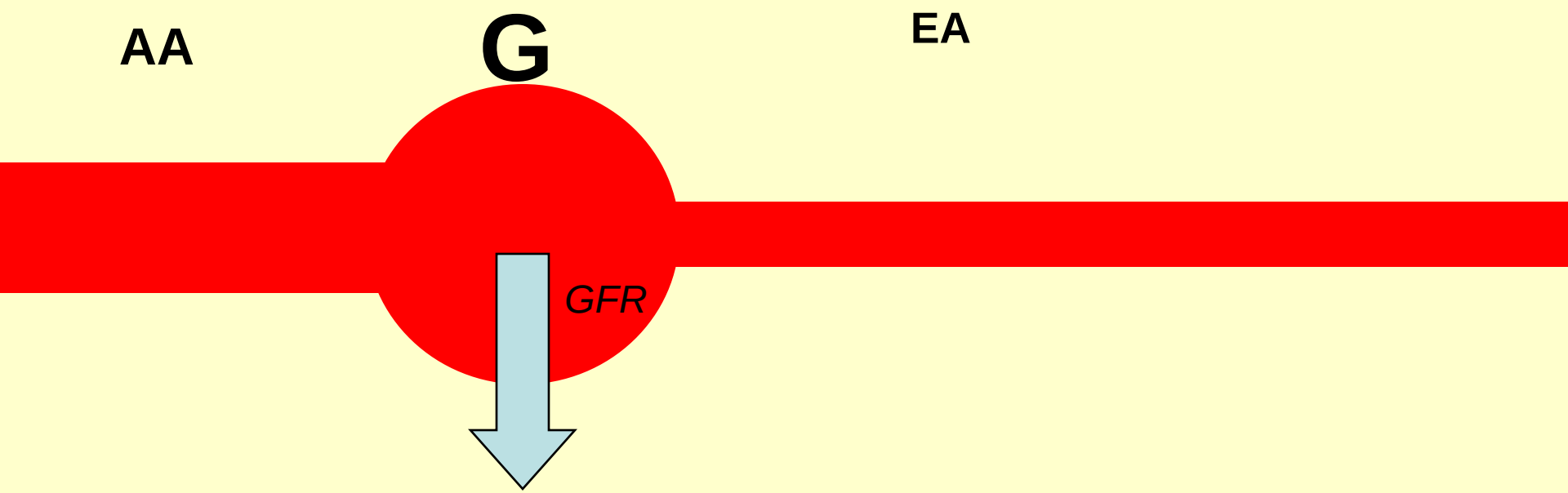
- Depends on...



# Maintaining Glomerular Filtration Rate



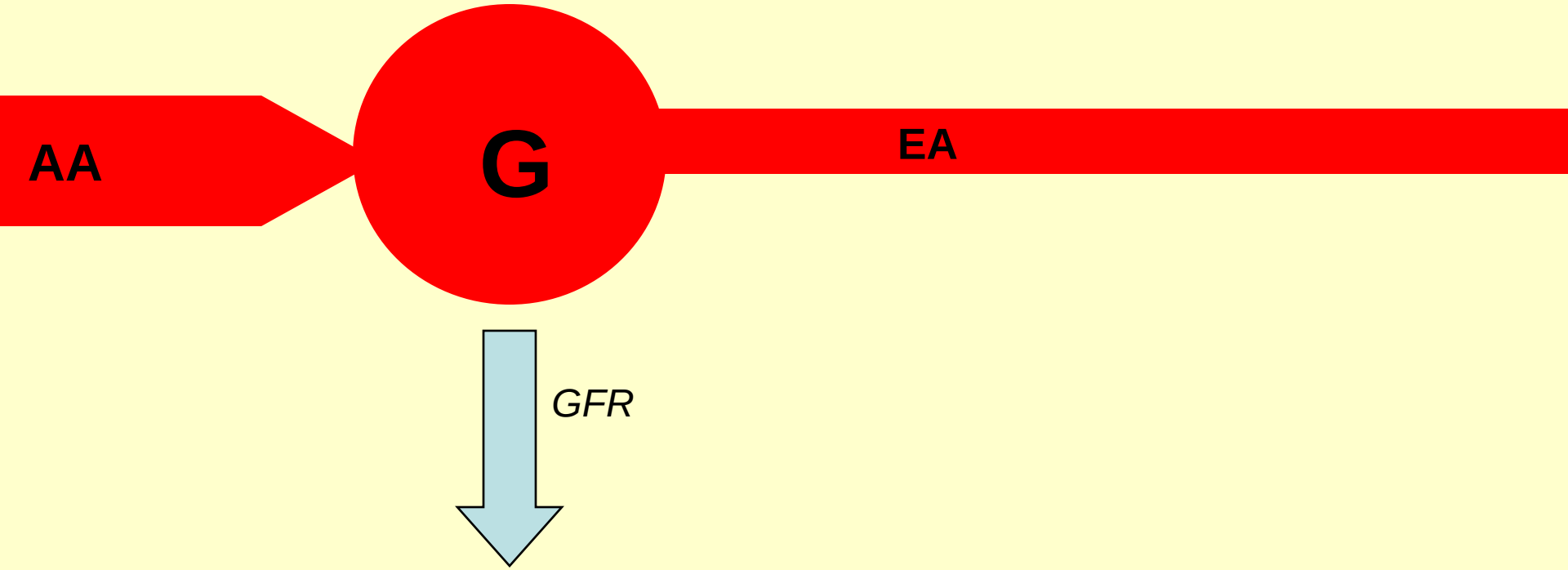
# Myogenic Mechanism of Maintaining GFR




Normal Situation

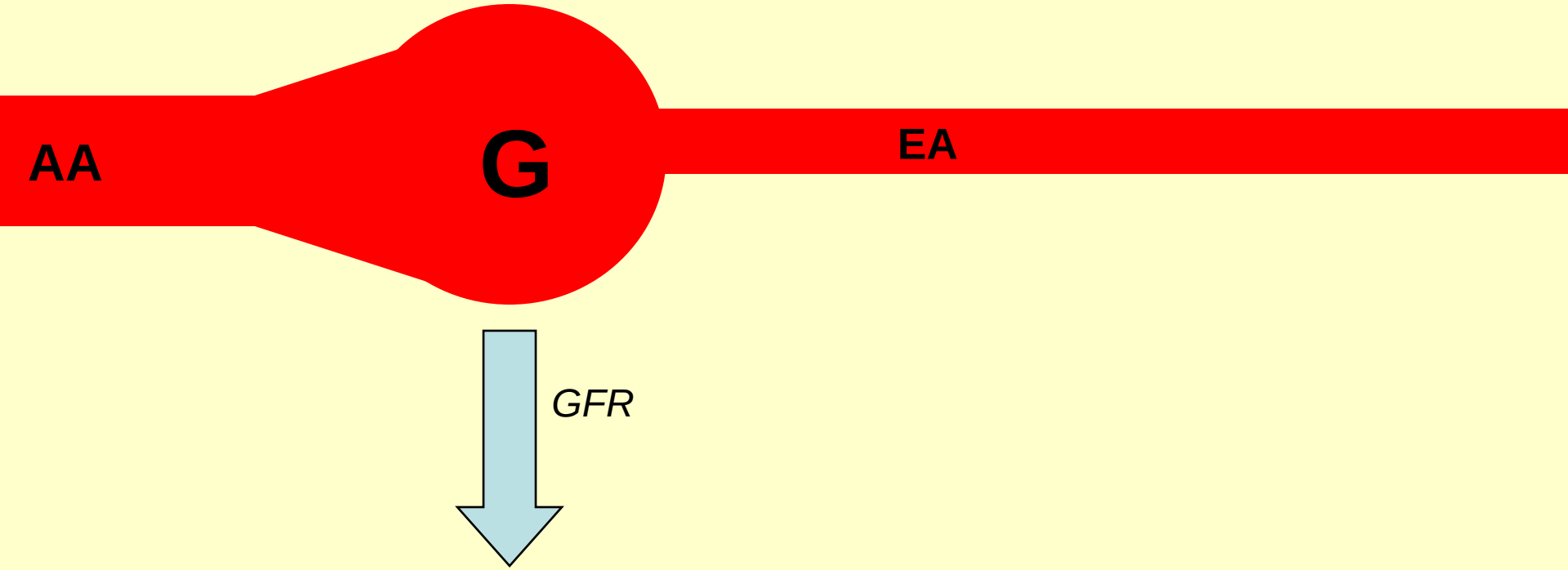
# Myogenic Mechanism of Maintaining GFR

Response to a rise in systemic BP



# Myogenic Mechanism of Maintaining GFR

Response to a fall in systemic BP



# Tubuloglomerular Mechanism

**Decreased GFR**

↓

**Filtrate flows _____**

↓

**_____NaCl in the filtrate reaching the DCT**

↓

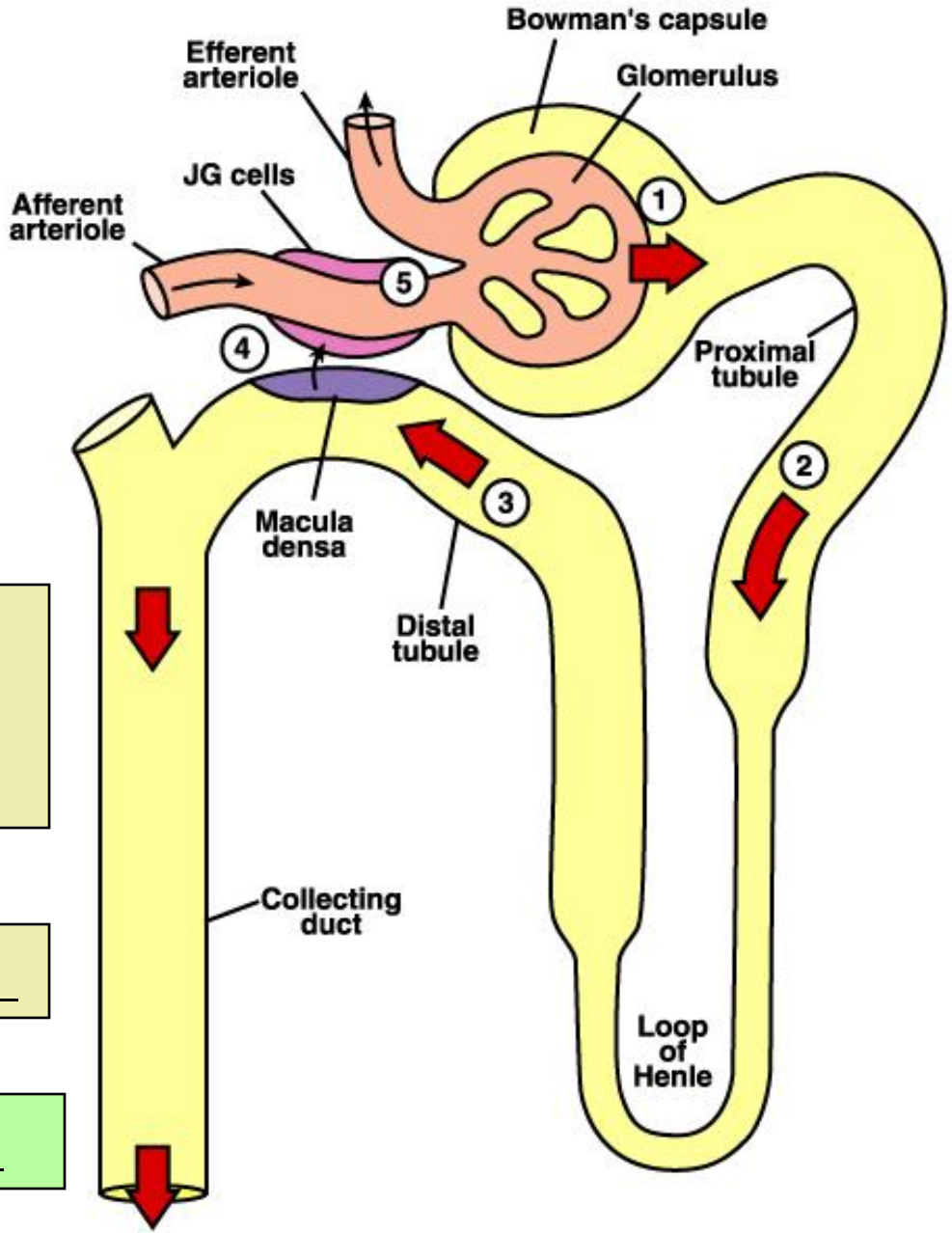
**Macula densa cells recognize NaCl and decrease vasoconstrictor release**

↓

**Afferent arteriole _____**

↓

**GBP and GFR _____**



# Effect of the Sympathetic Nervous System

***Increased sympathetic activity***

↓

***NE and E cause afferent arteriole to constrict***

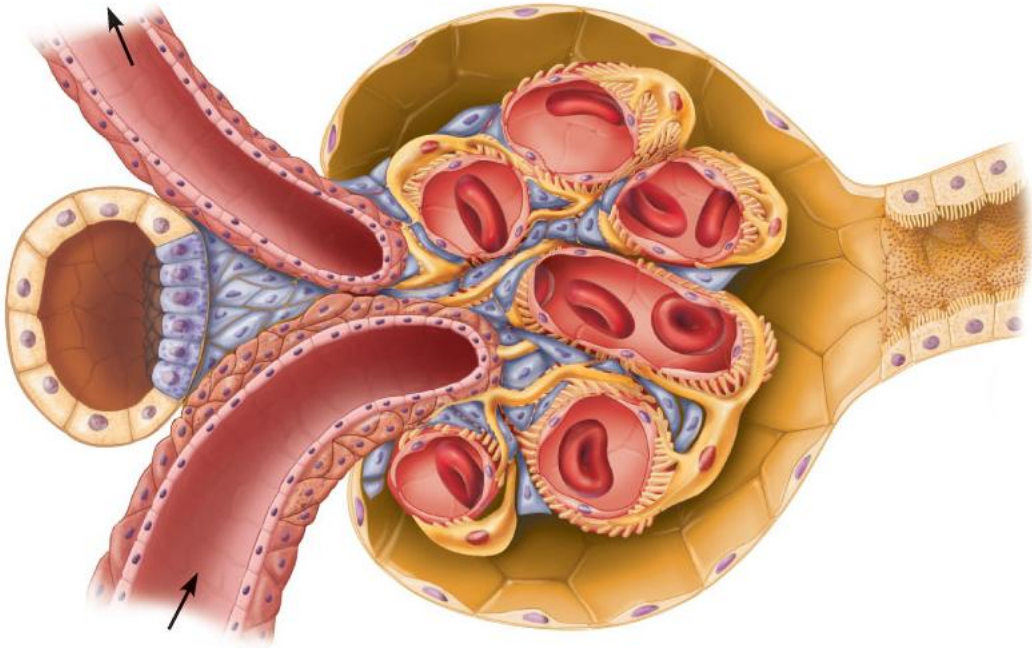
↓

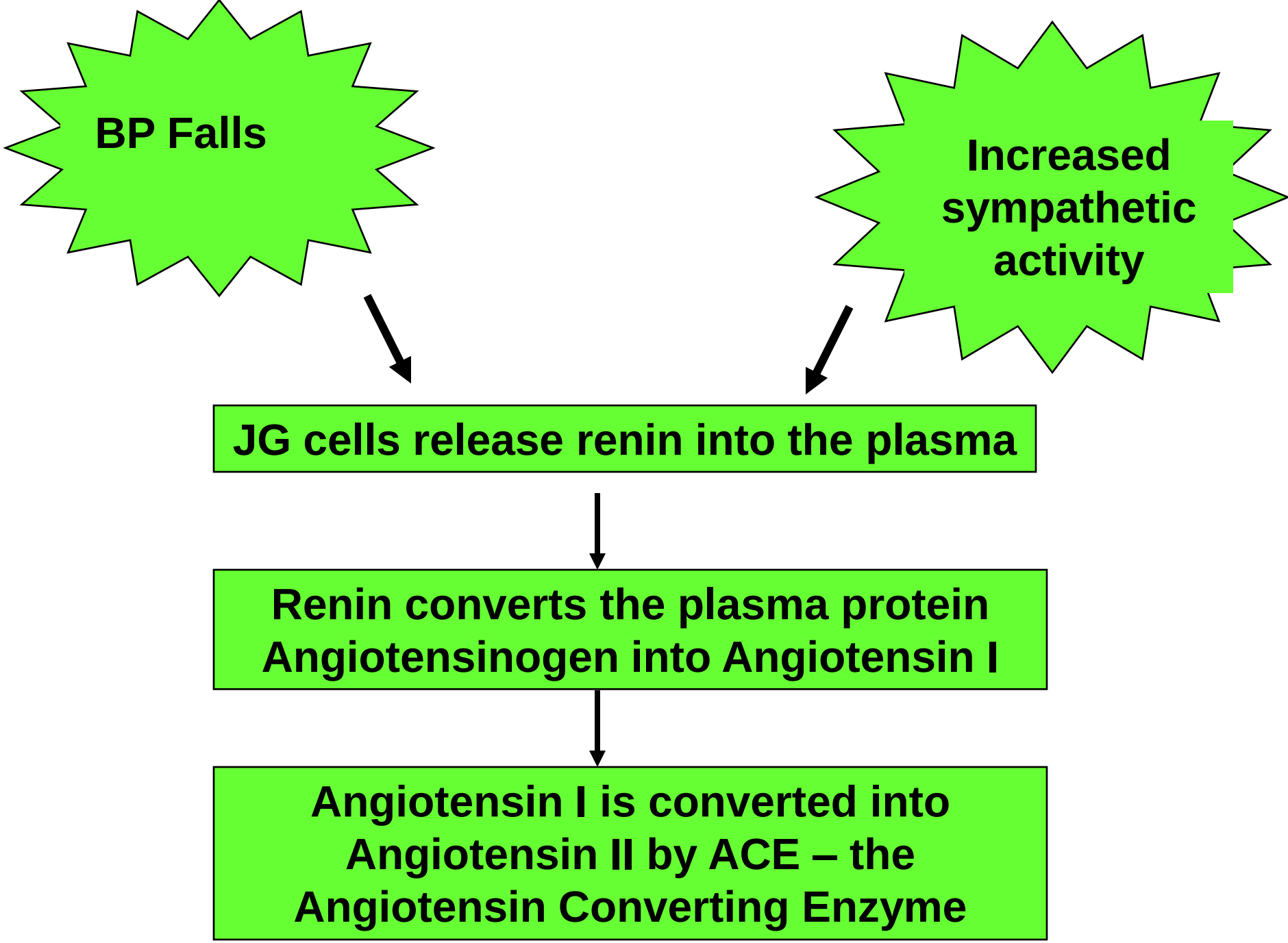
***GBP and thus GFR fall***

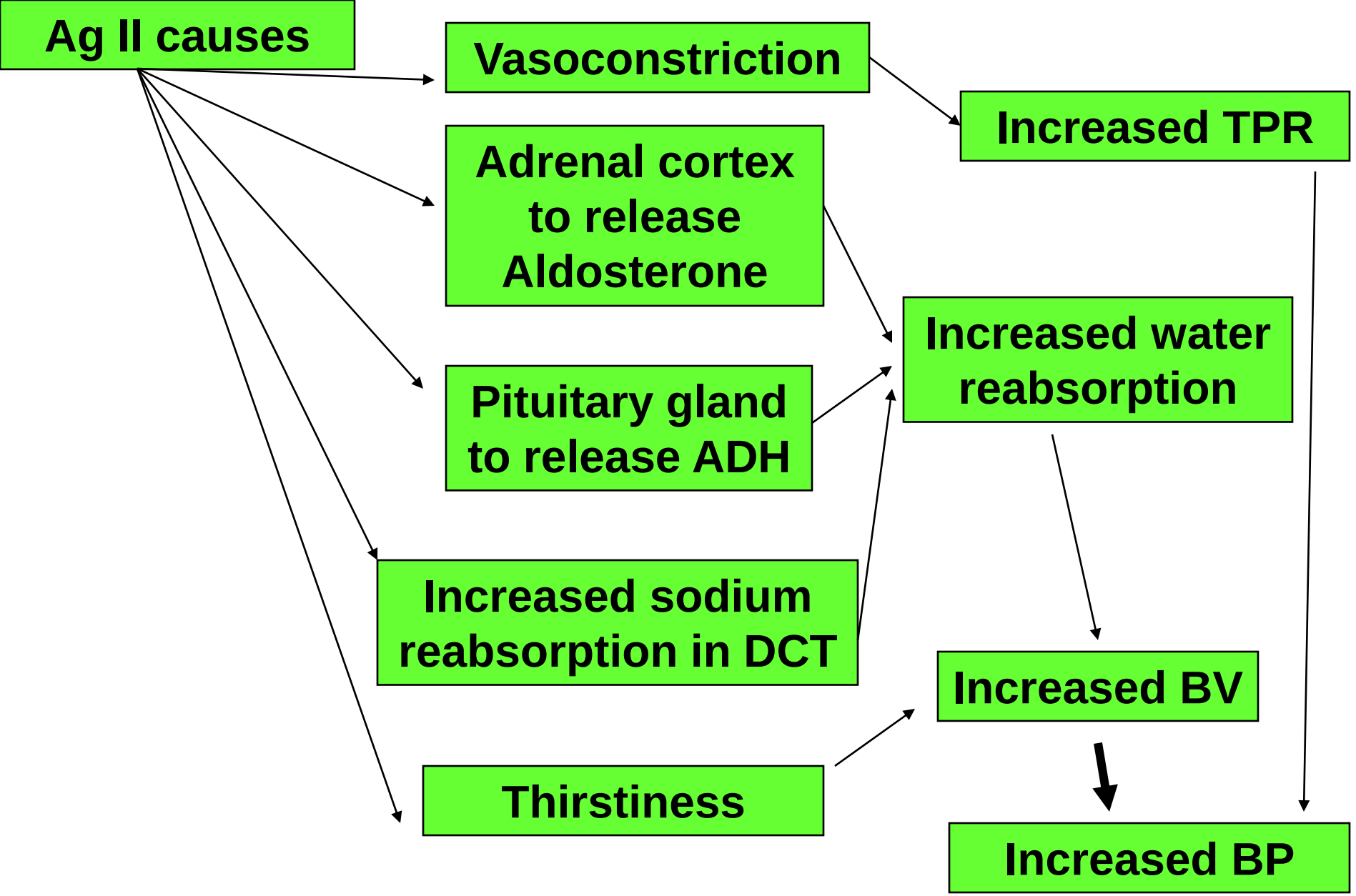
***What is an advantage of this process?***

# Renin-Angiotensin System

- Protects against...
- Initiated by the release…
- Also by…



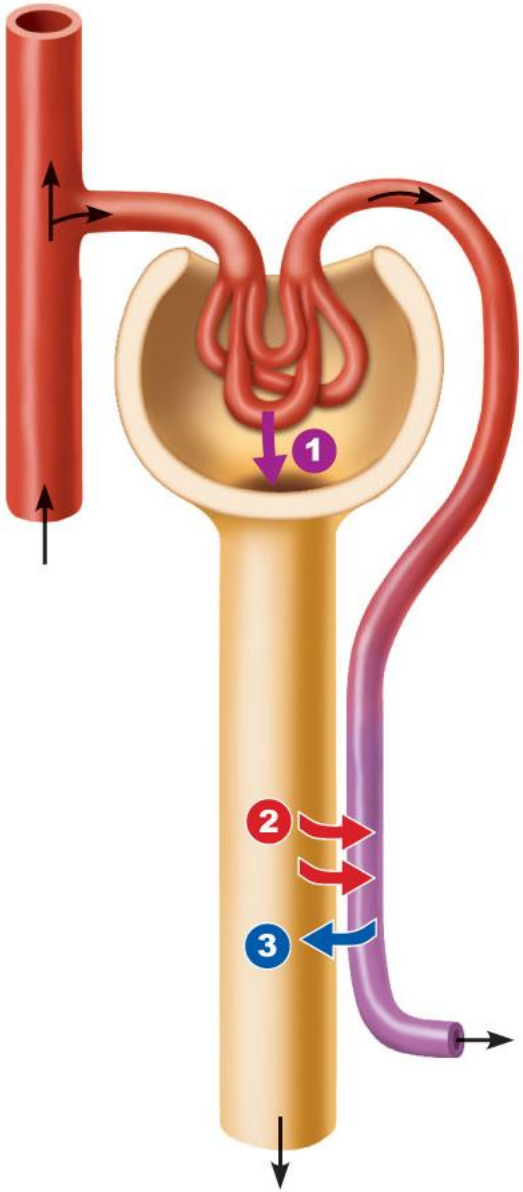

BP Falls
Increased sympathetic activity
JG cells release renin into the plasma
Renin converts the plasma protein Angiotensinogen into Angiotensin I
Angiotensin I is converted into Angiotensin II by ACE – the Angiotensin Converting Enzyme


Ag II causes
Vasoconstriction
Increased TPR
Adrenal cortex to release Aldosterone
Increased water reabsorption
Pituitary gland to release ADH
Increased sodium reabsorption in DCT
Increased BV
Thirstiness
Increased BP

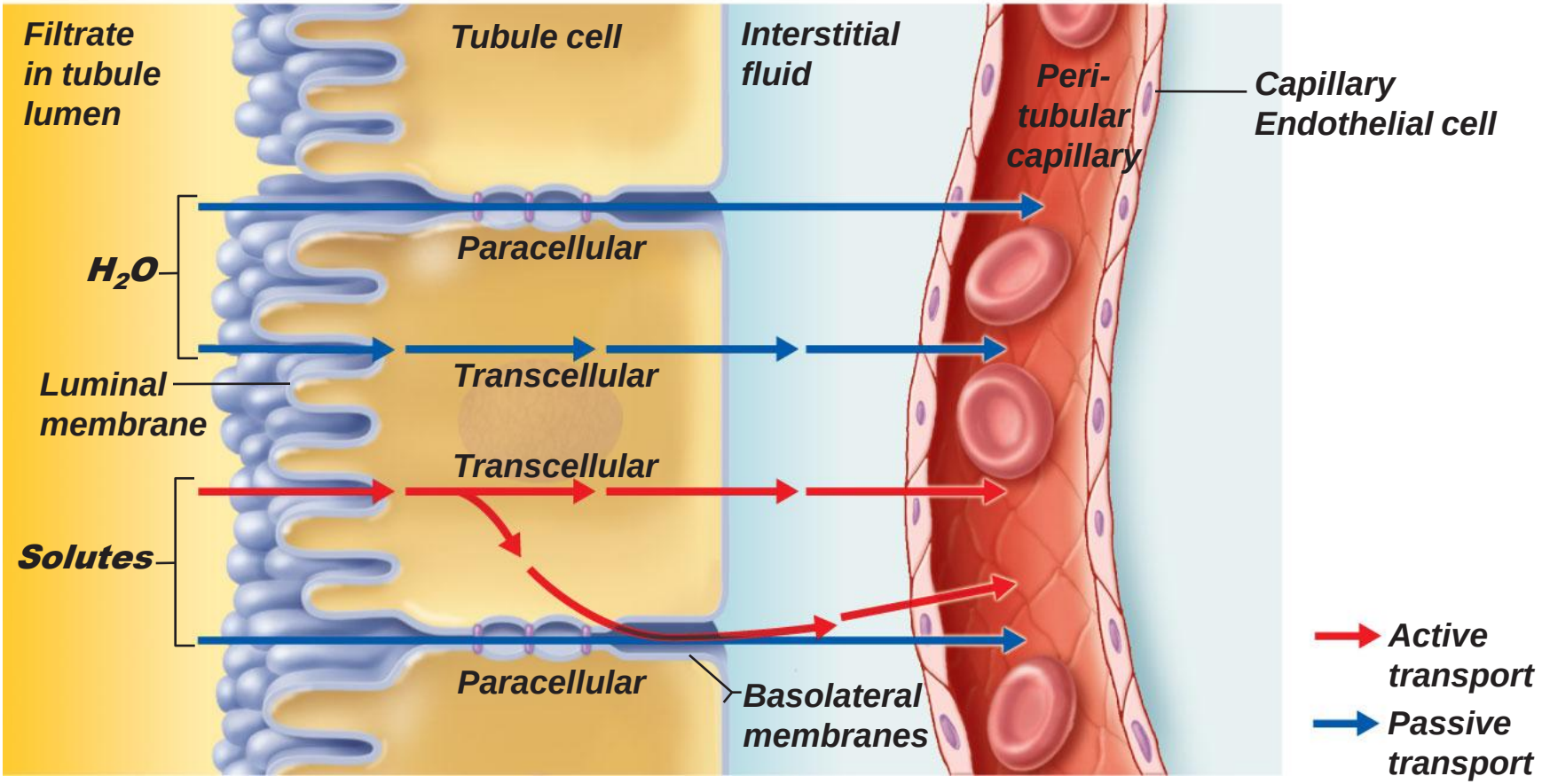
# PCT Reabsorption

- *What kind of "stuff" needs to be reabsorbed?*

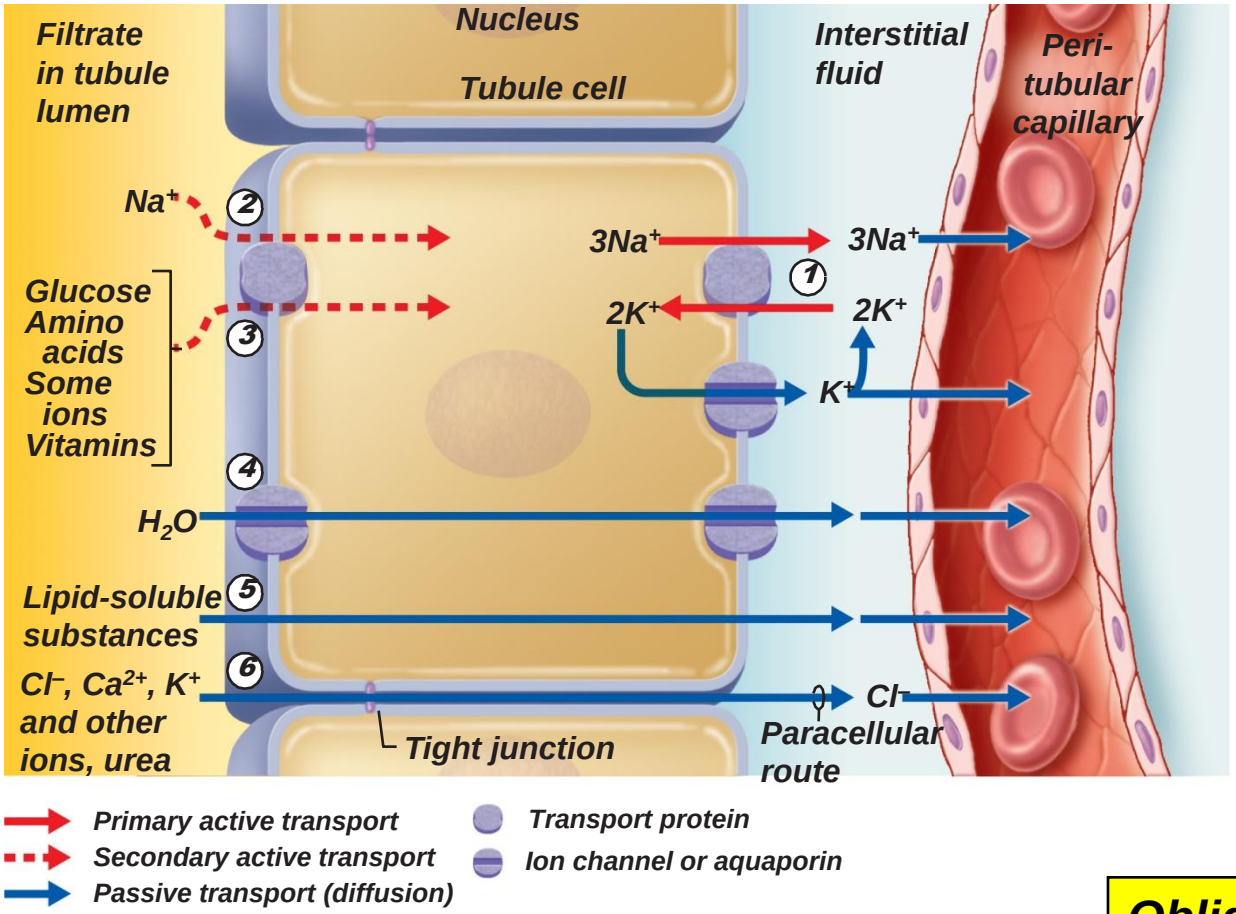
- Reabsorbed molecules travel from the _____ to the _____.



# PCT Reabsorption

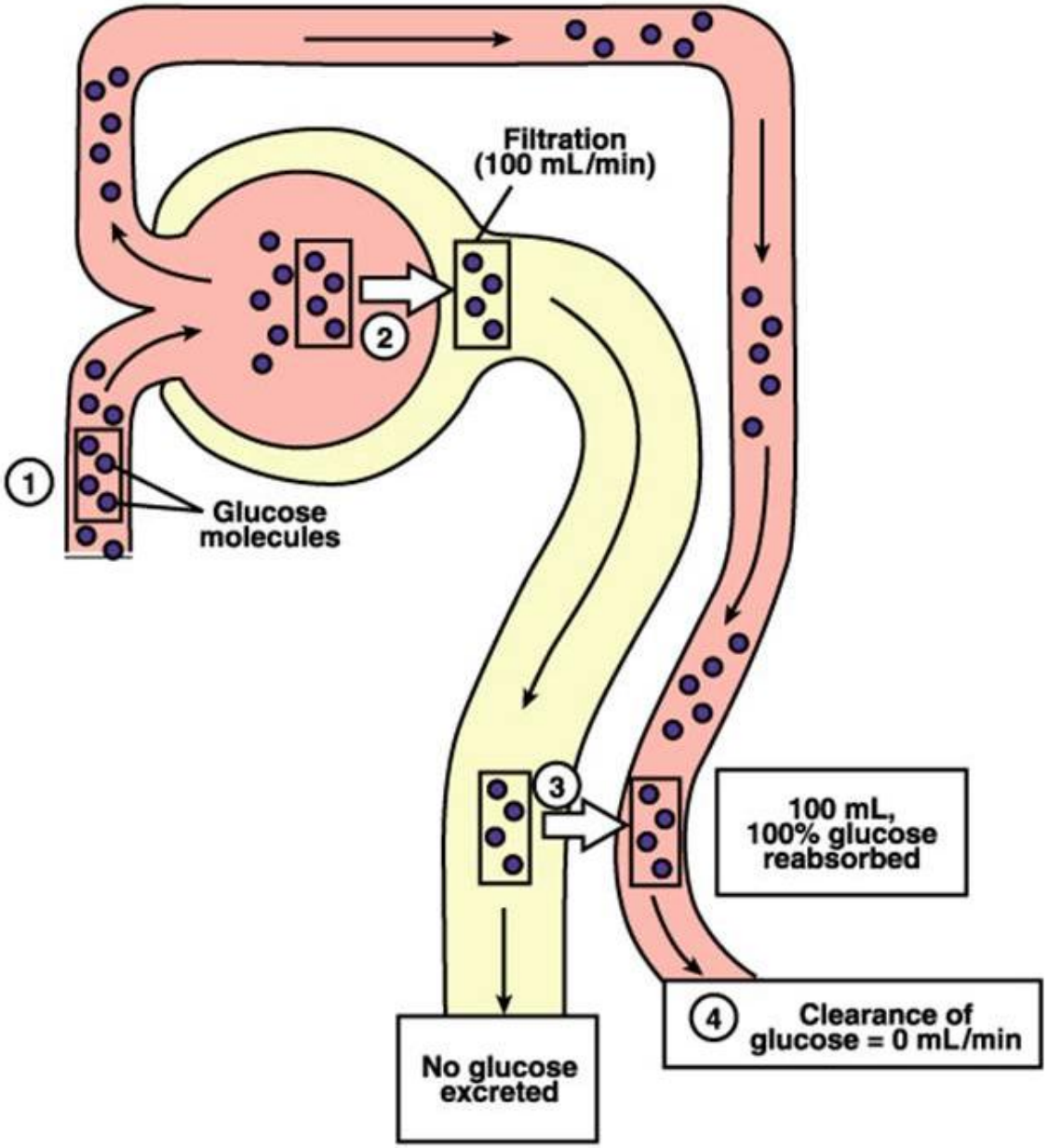


# PCT Reabsorption



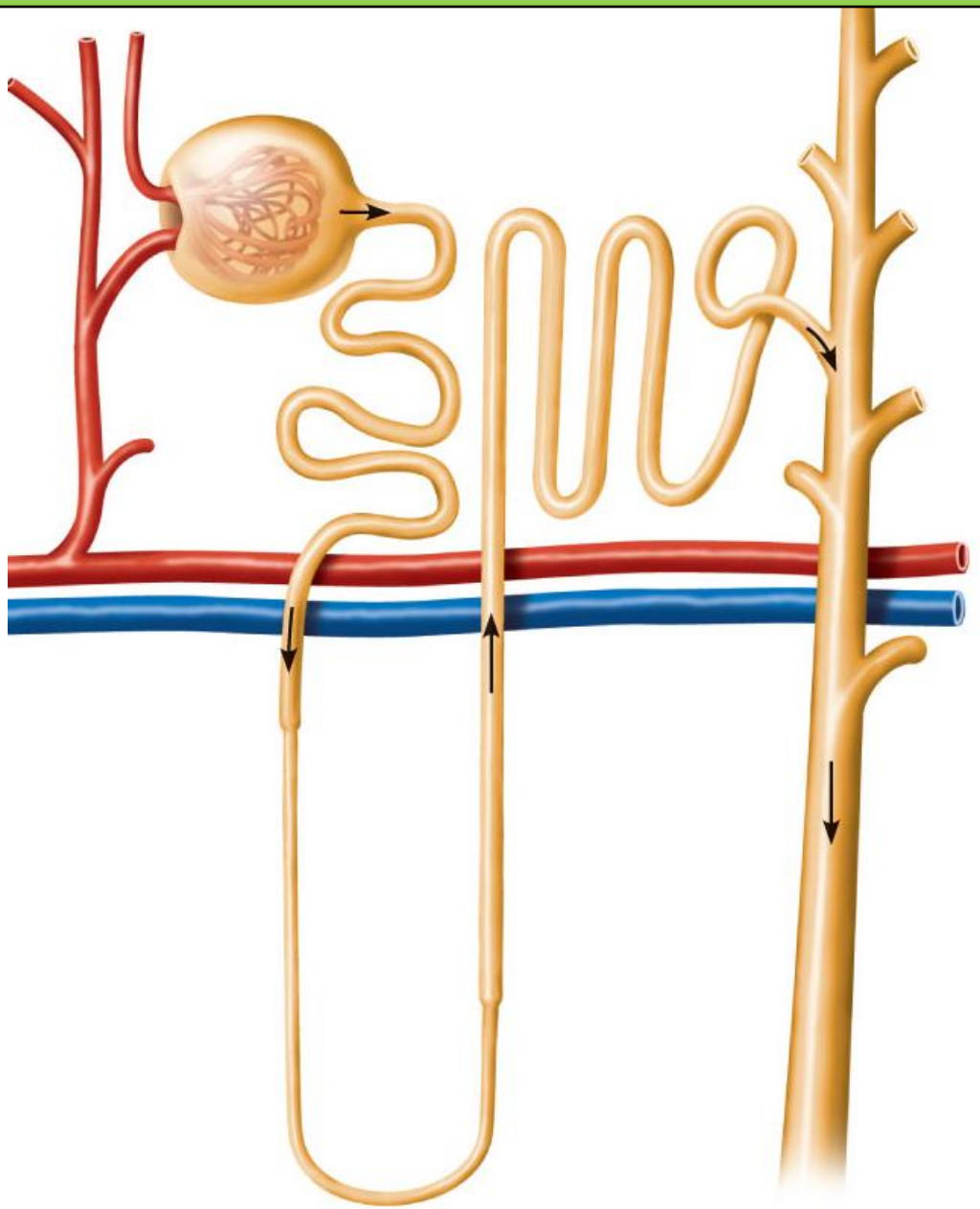

**Obligatory reabsorption**

# Transport Maximum



# DCT Reabsorption

- Hormone dependent
- Fine tuning
- Aldosterone
- Parathyroid hormone

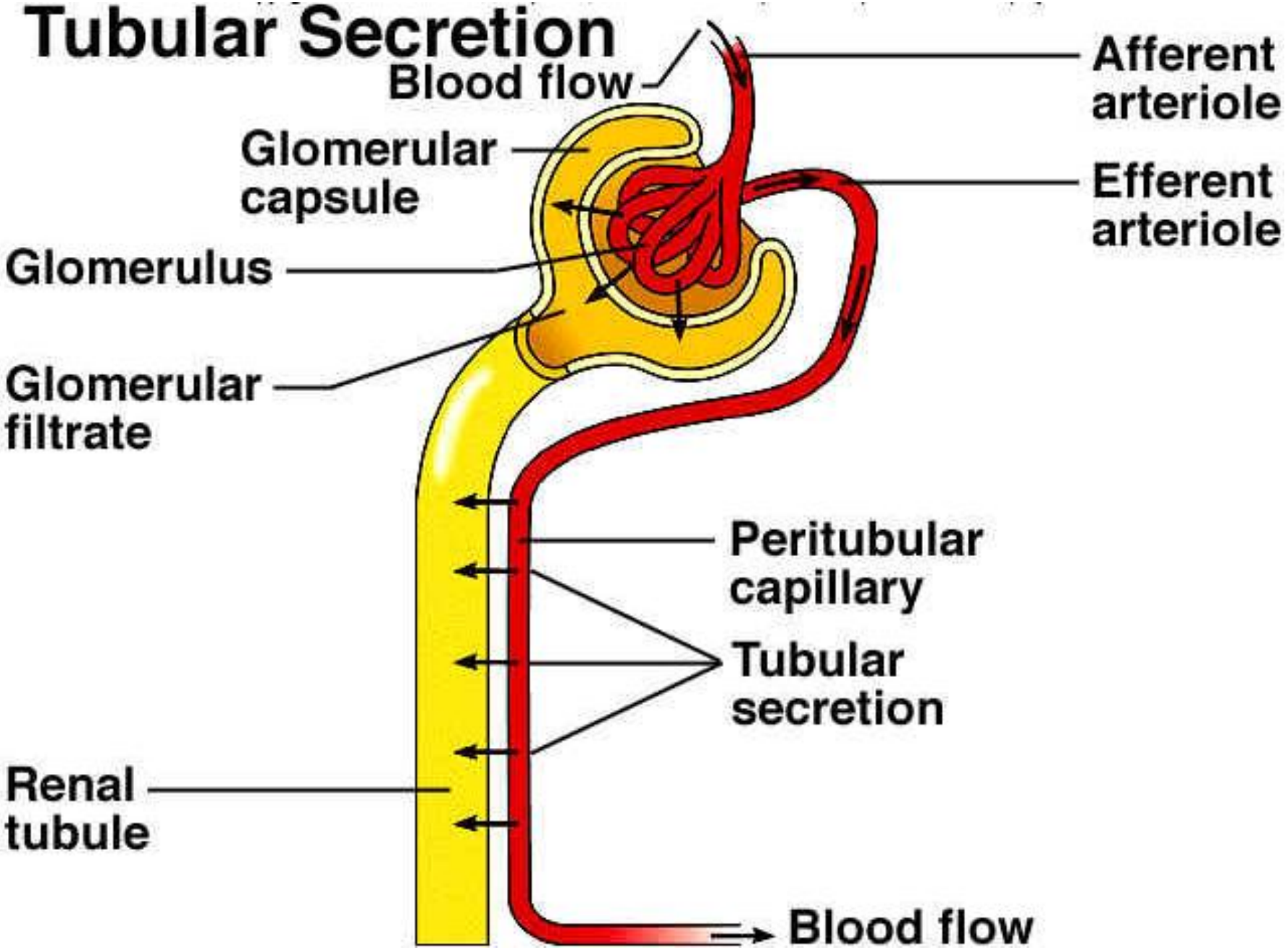


# Loop of Henle Reabsorption

- Descending limb
- Ascending limb
- Urine concentration

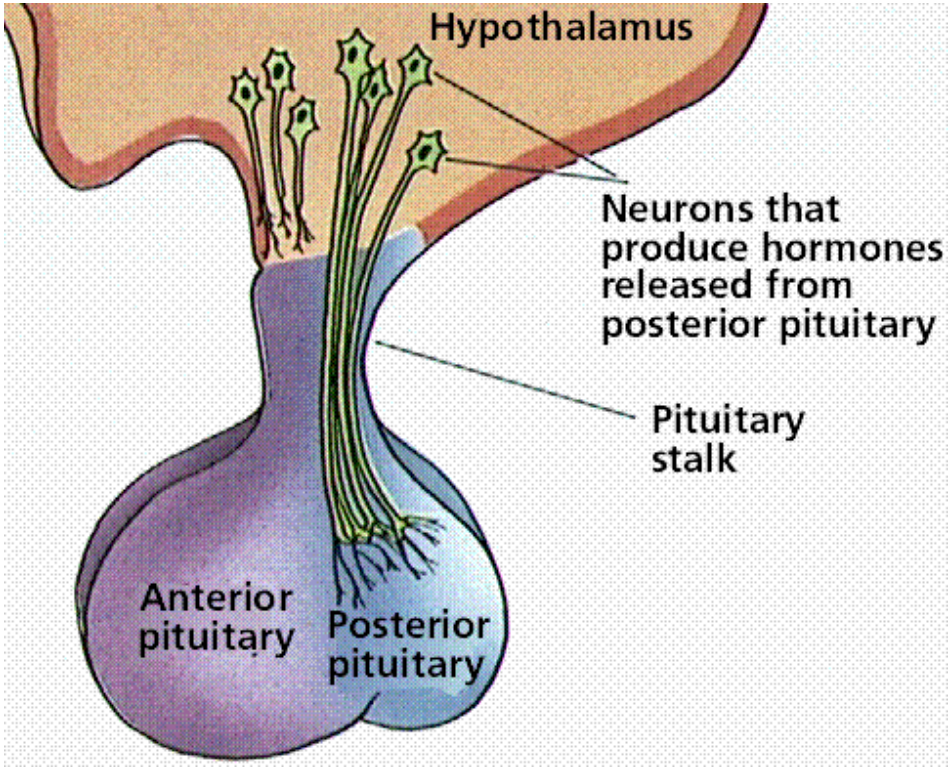
# Collecting Duct Reabsorption

- Water
- Depends on body's hydration levels
- Antidiuretic hormone

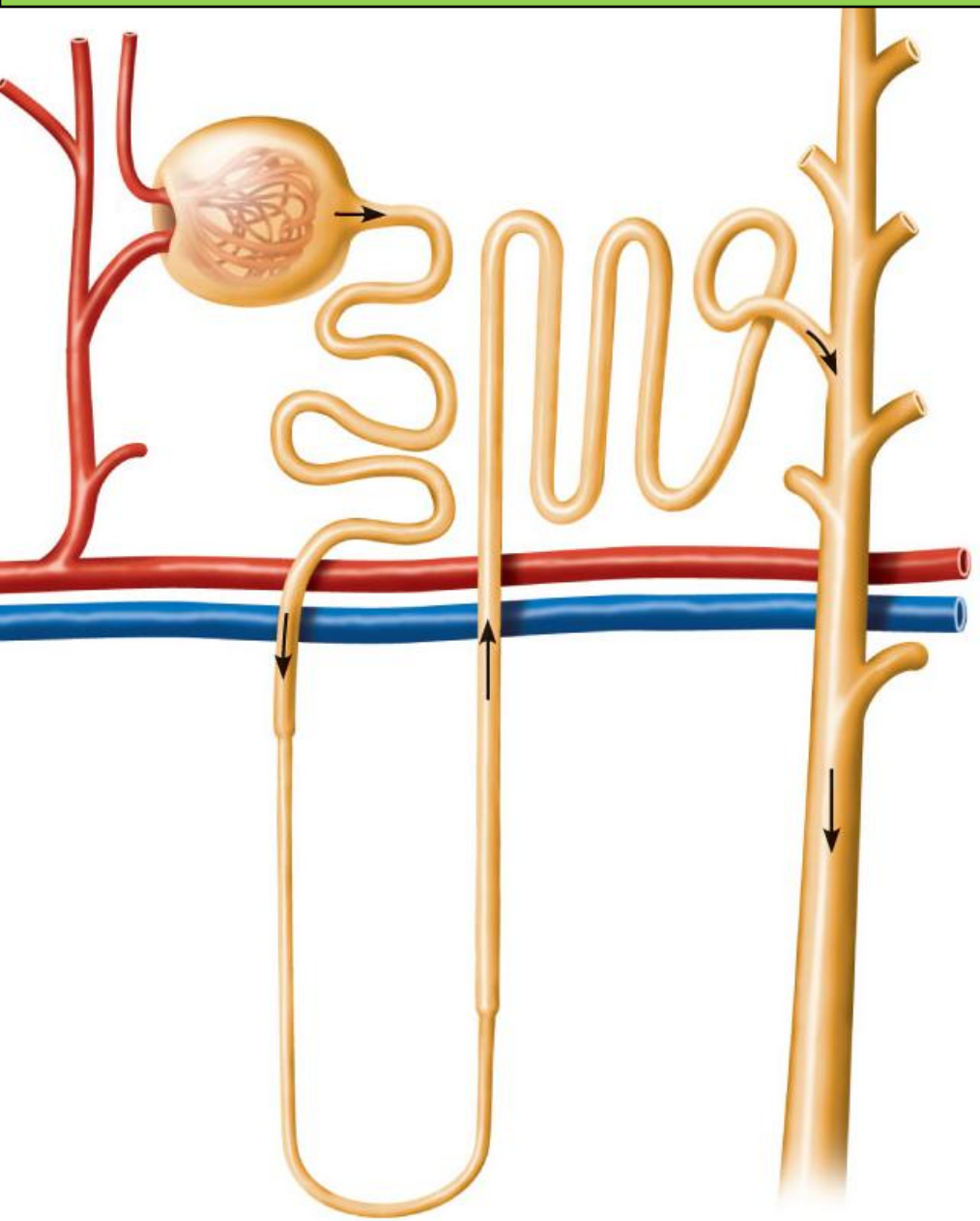

Tubular Secretion
Blood flow
Afferent arteriole
Glomerular capsule
Efferent arteriole
Glomerulus
Glomerular filtrate
Peritubular capillary
Tubular secretion
Renal tubule
Blood flow

# Regulating Blood Concentration

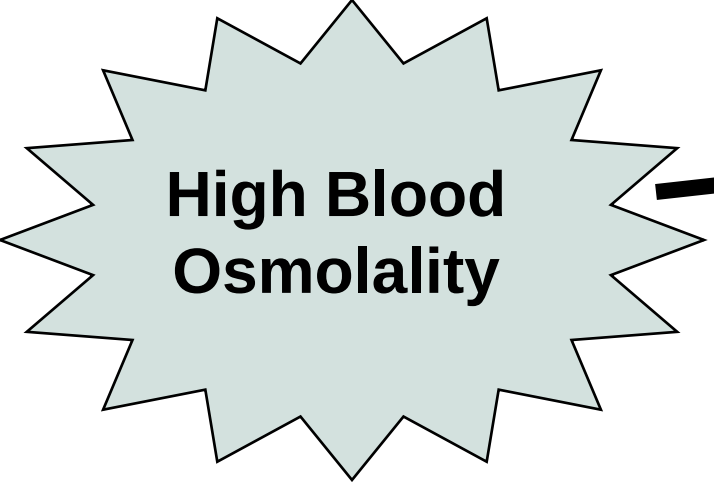
- Plasma osmolality.
- Measuring it.
- Adjusting it.
- Antidiuretic hormone



# Regulating Blood Concentration



ADH increases the reabsorption of water from the collecting duct.




Sensed by osmoreceptors in the hypothalamus

Posterior pituitary gland increases ADH release

ADH increases the permeability of the collecting duct to water

Increased water reabsorption

Blood osmolality falls

***Facultative reabsorption***

# What will increased ADH do to:

- Water reabsorption
- Urine output
- Urine color
- Blood volume
- Blood pressure

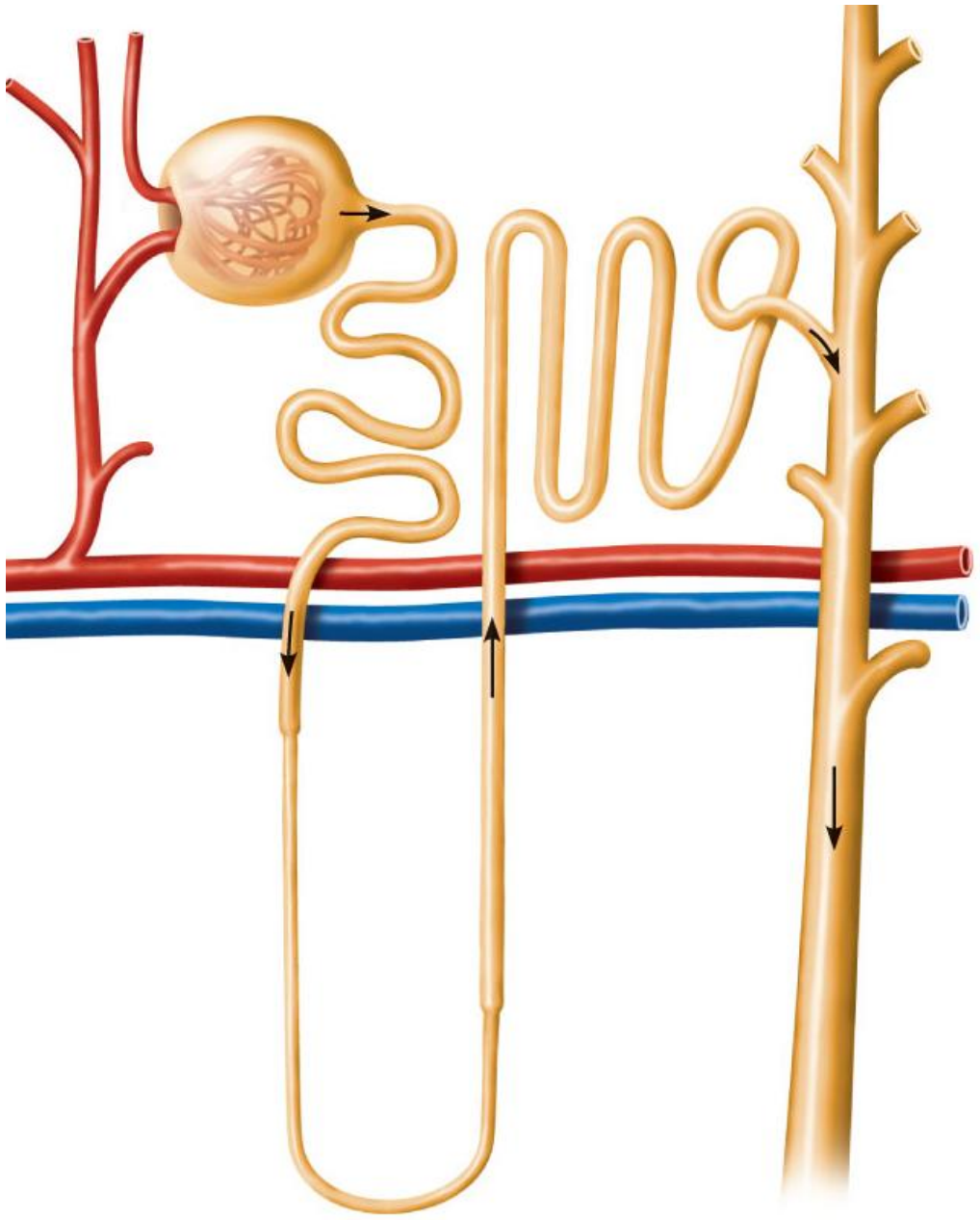
This the MRI of a girl with a tumor called a craniopharyngioma.

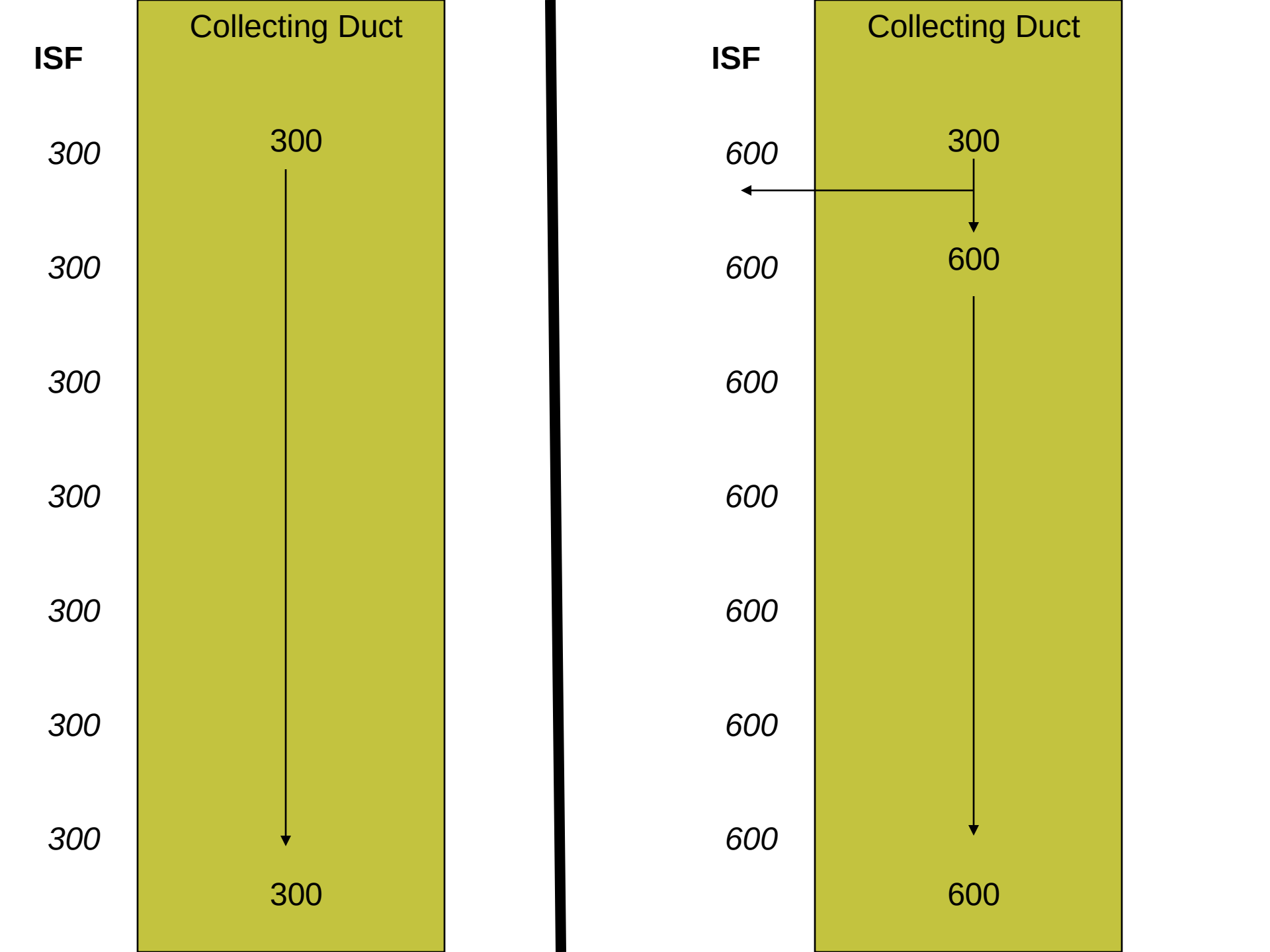
The girl often complained of extreme thirst and an almost constant need to urinate.

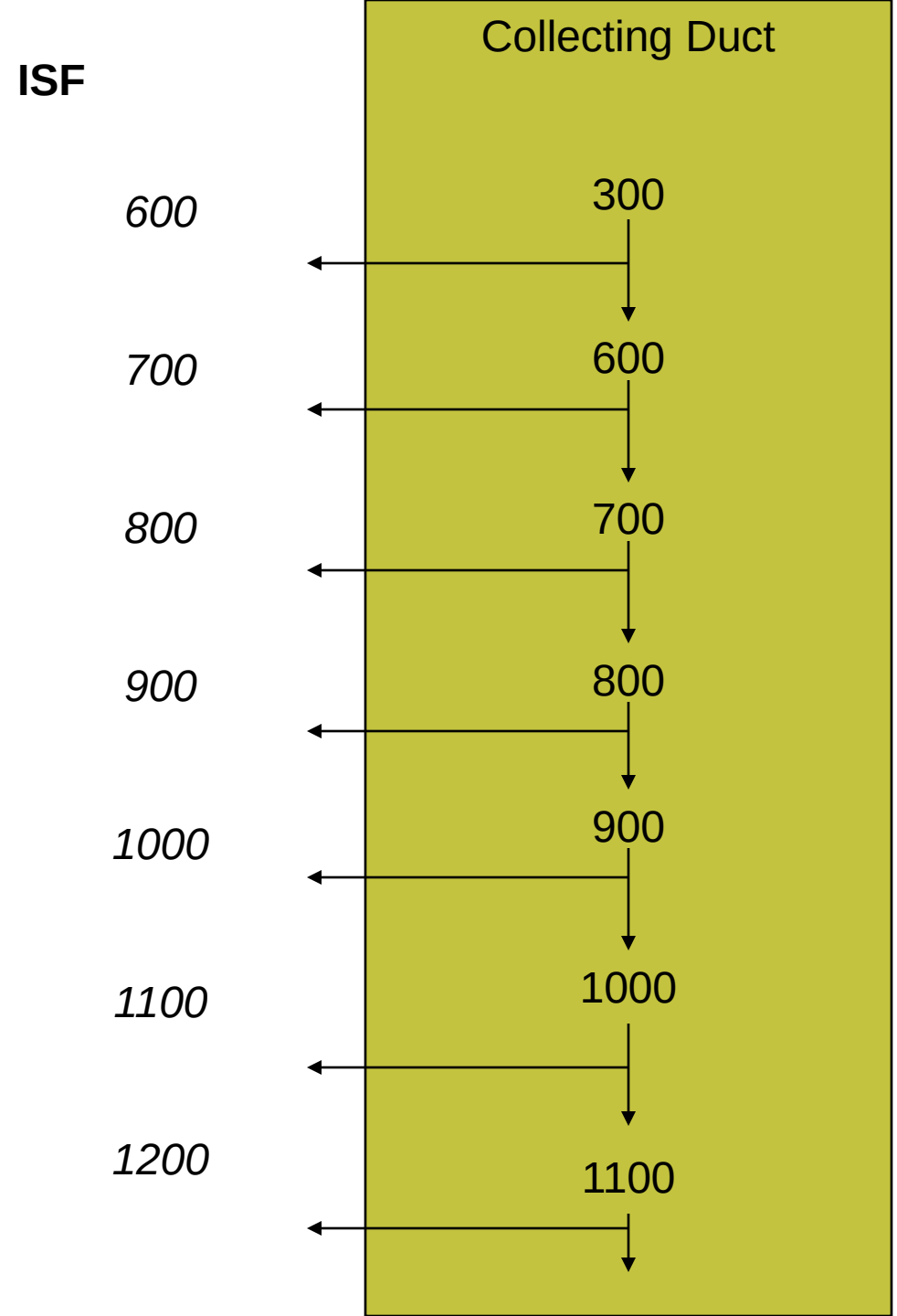
*What brain structure do you suppose is not functioning properly?*

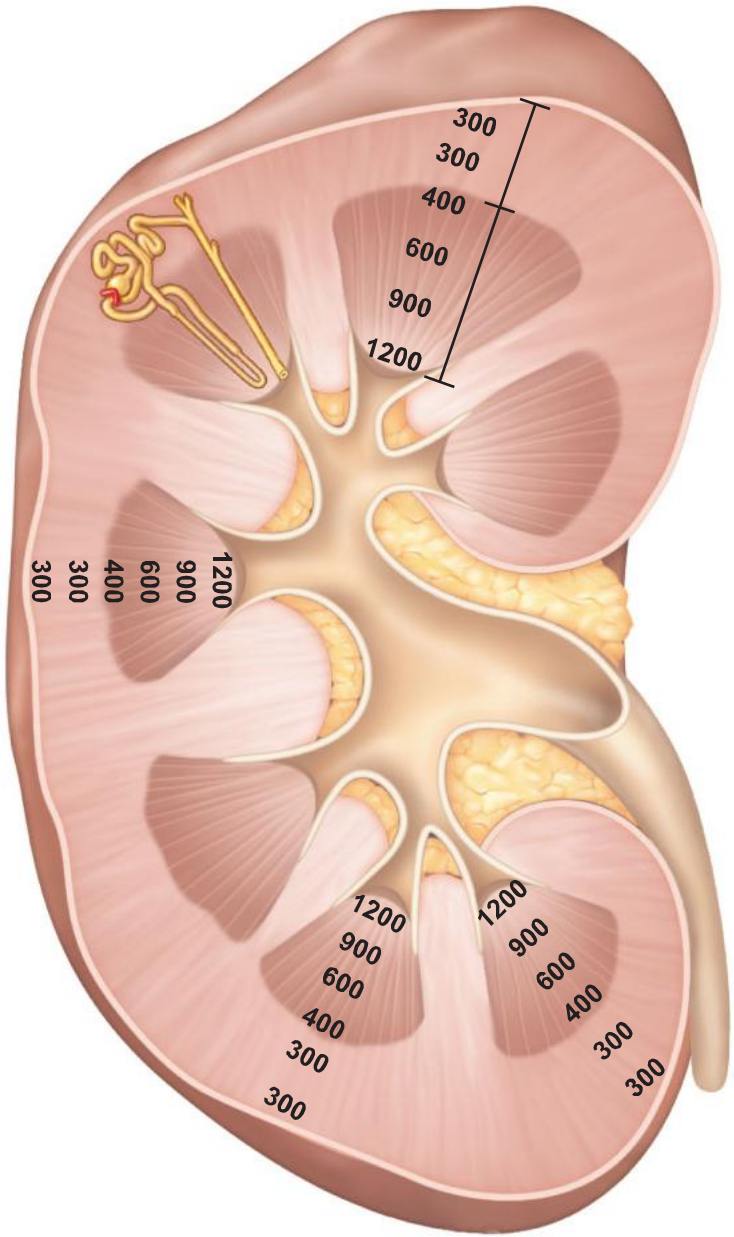
ADH makes the collecting duct more permeable to water.

*What else must exist in order for water reabsorption to occur?*

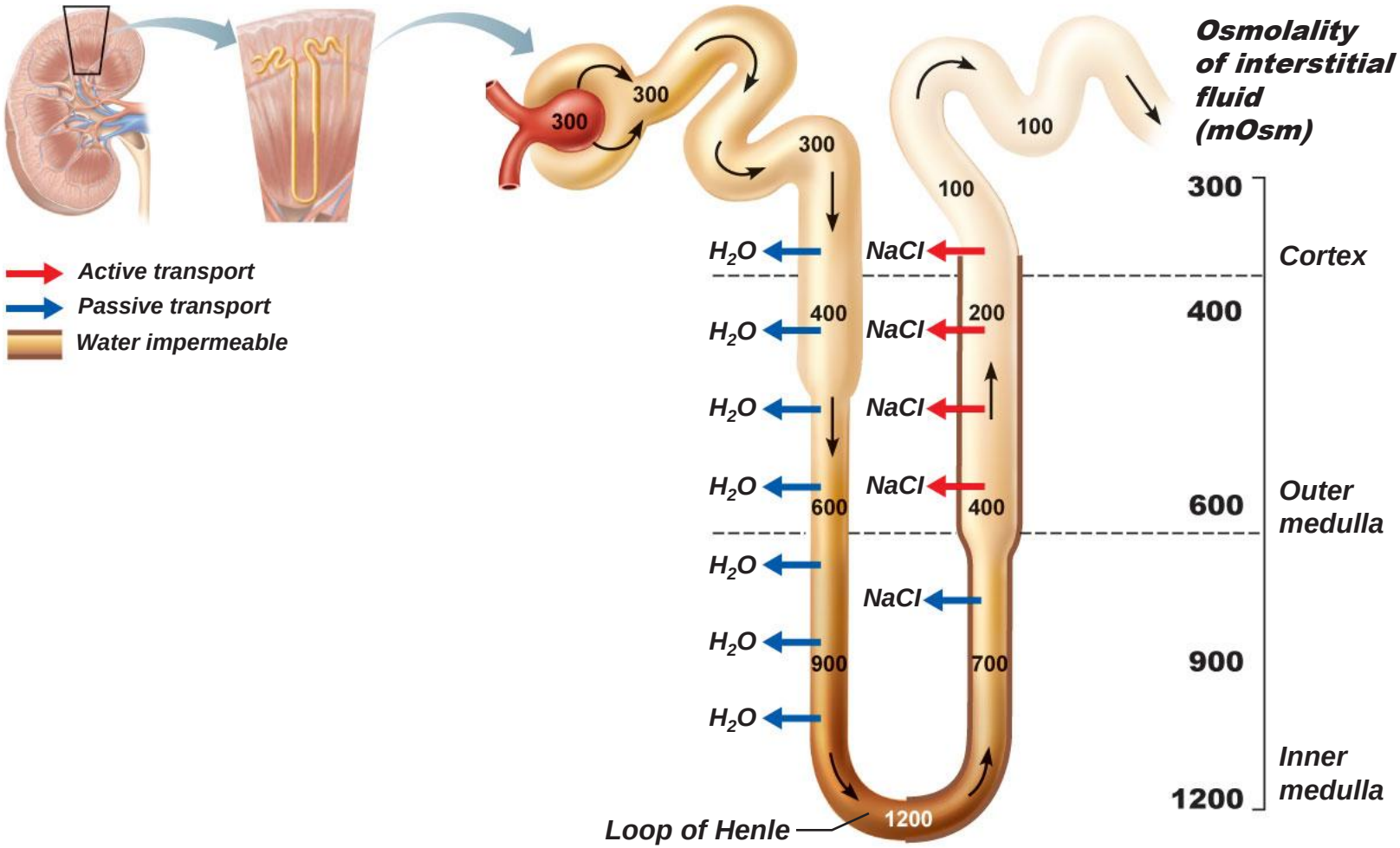


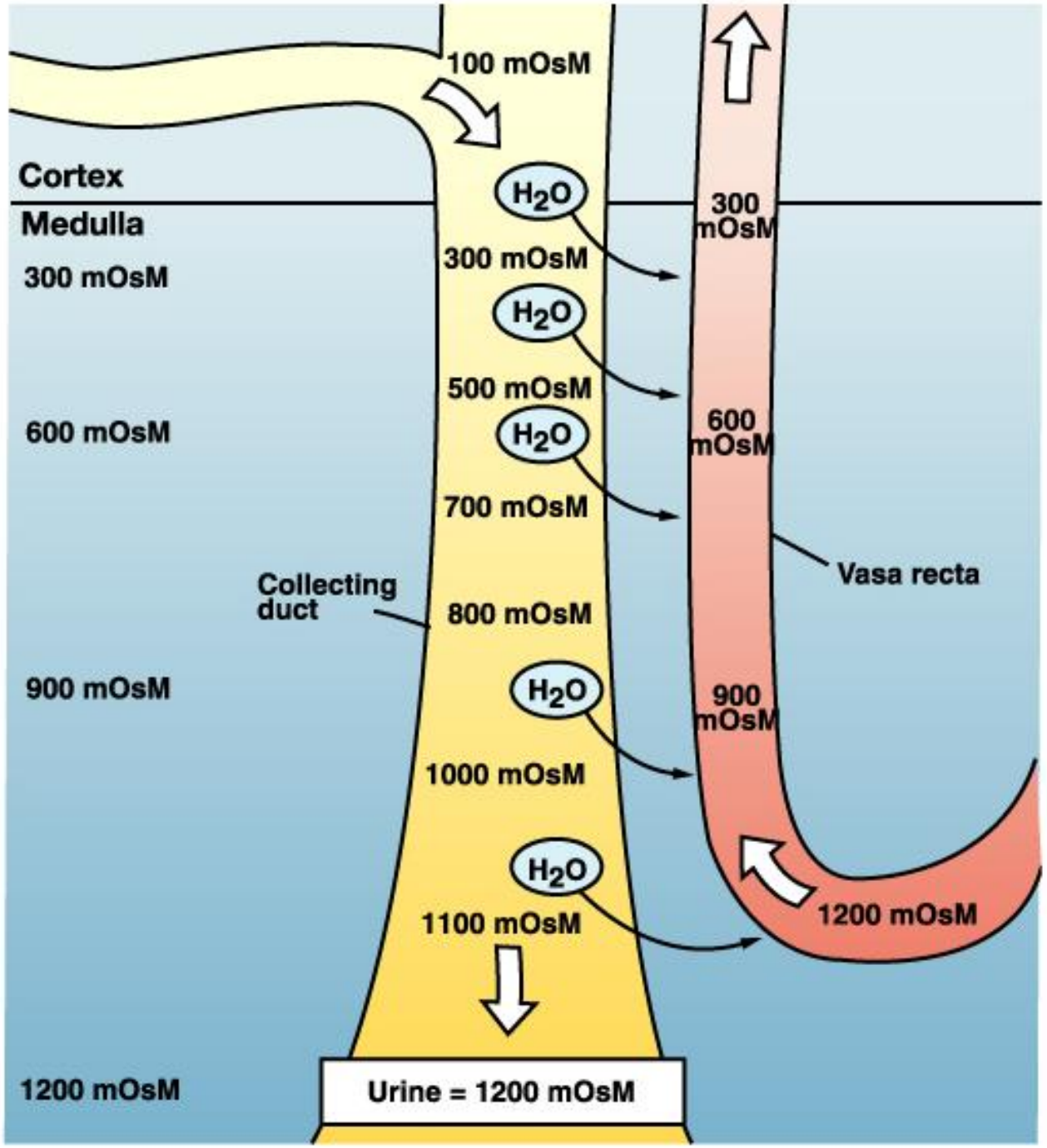

ISF
Collecting Duct
300
300
300
300
300
300
300
300
300
300
ISF
Collecting Duct
300
600
600
600
600
600
600
600
600
600

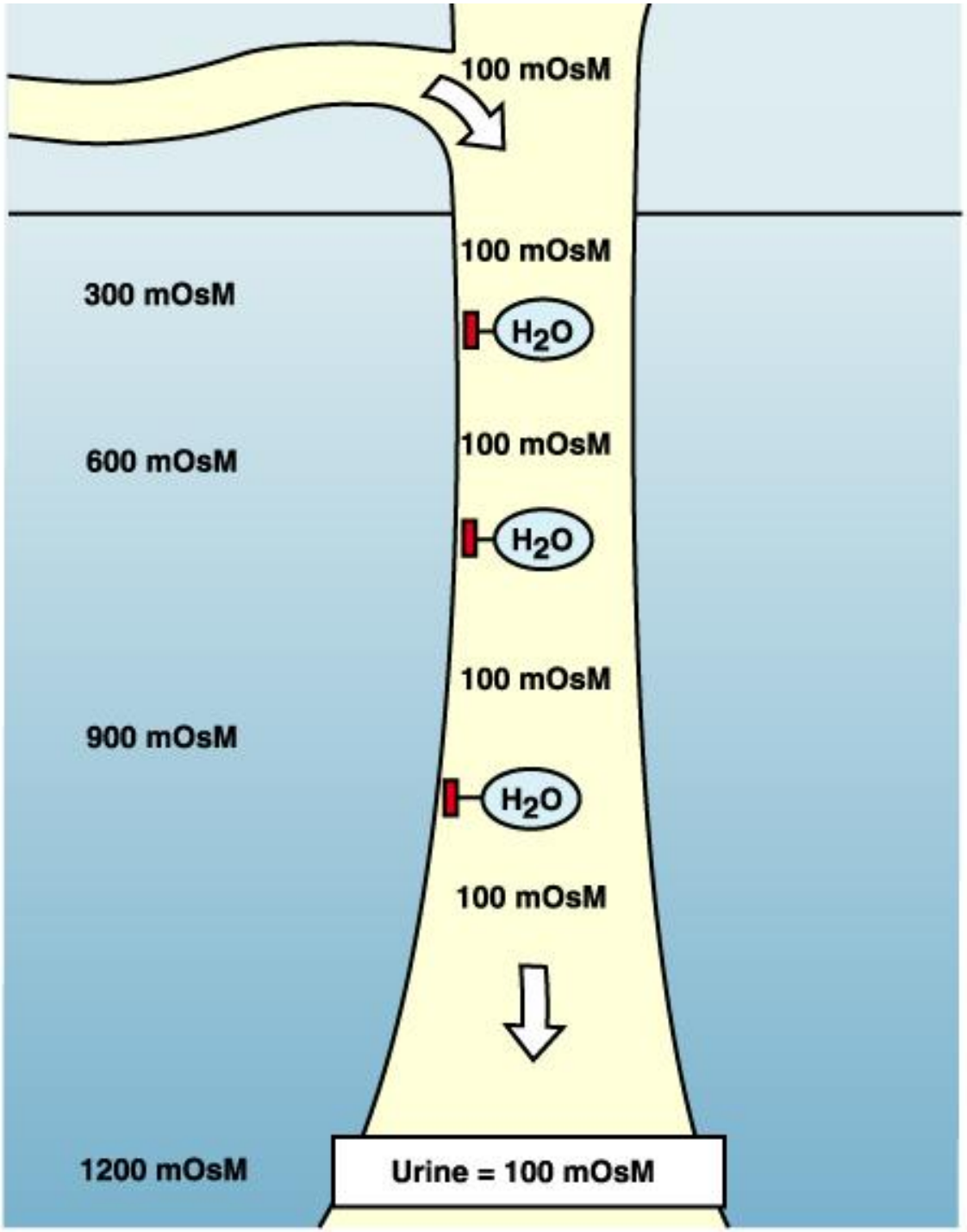

ISF
Collecting Duct
600
300
700
600
800
700
900
800
1000
900
1100
1000
1200
1100

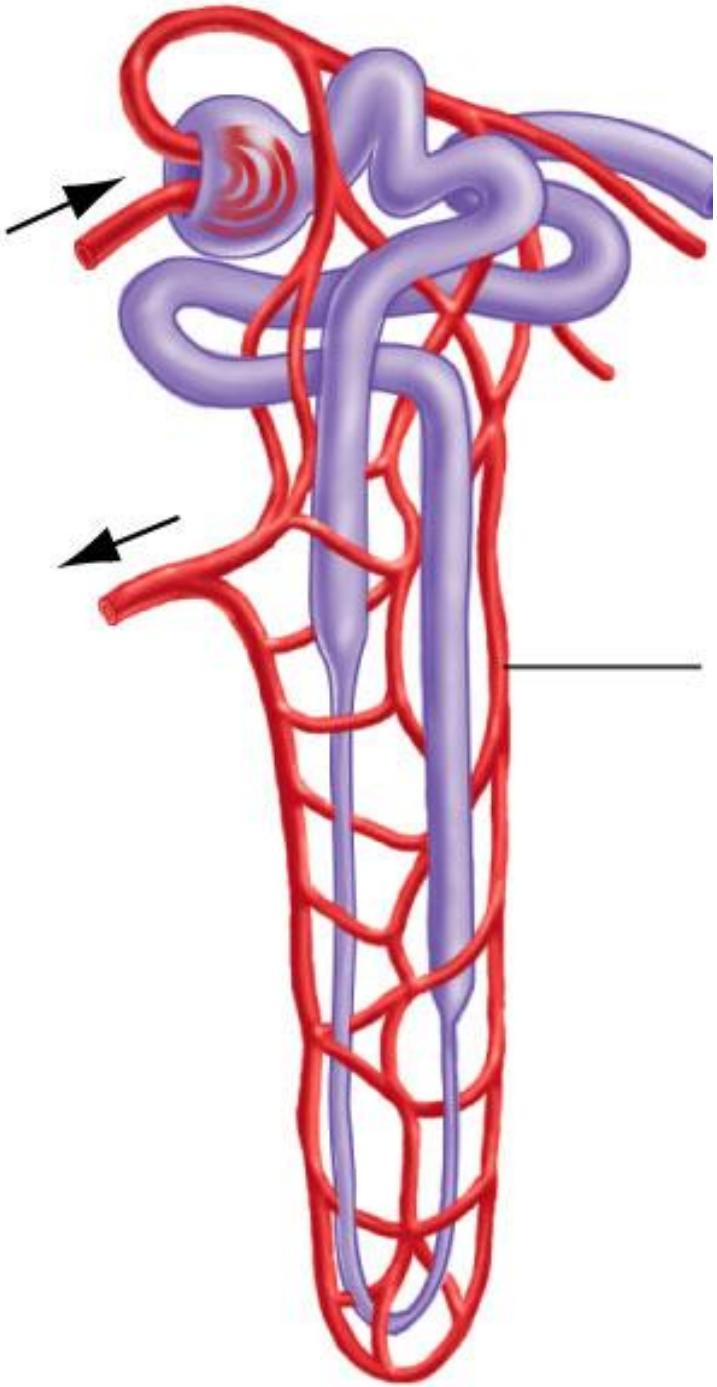

300
300
400
600
900
1200
300
300
400
600
900
1200
1200
900
600
400
300
300
1200
900
600
400
300
300

# Medullary Osmotic Gradient



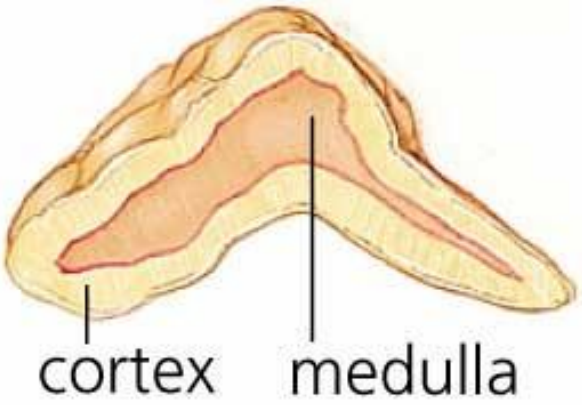

100 mOsM
Cortex
Medulla
300 mOsM
300 mOsM
H2O
300 mOsM
H2O
500 mOsM
600 mOsM
H2O
600 mOsM
700 mOsM
Vasa recta
Collecting duct
800 mOsM
900 mOsM
H2O
900 mOsM
1000 mOsM
H2O
1200 mOsM
1100 mOsM
1200 mOsM
Urine = 1200 mOsM

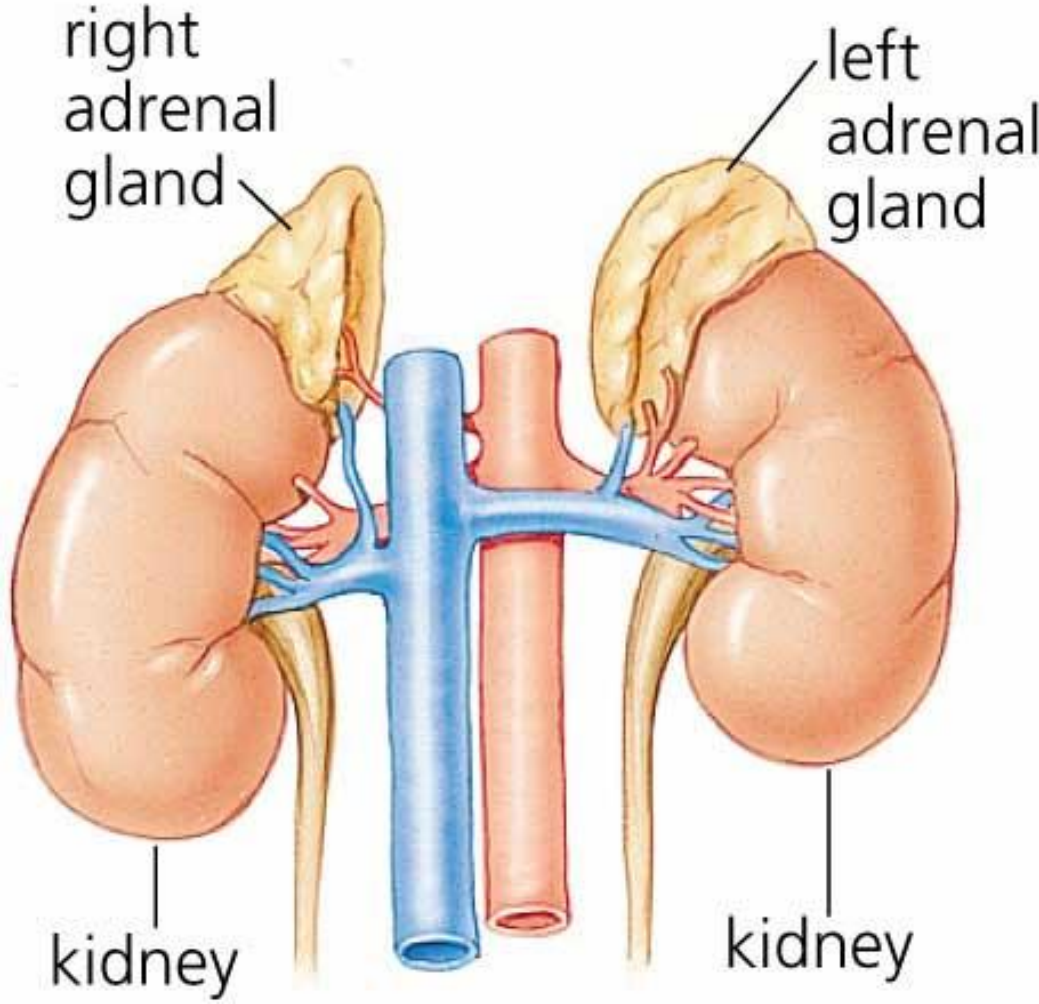

100 mOsM
100 mOsM
300 mOsM
$H_2O$
100 mOsM
600 mOsM
$H_2O$
100 mOsM
900 mOsM
$H_2O$
100 mOsM
1200 mOsM
Urine = 100 mOsM

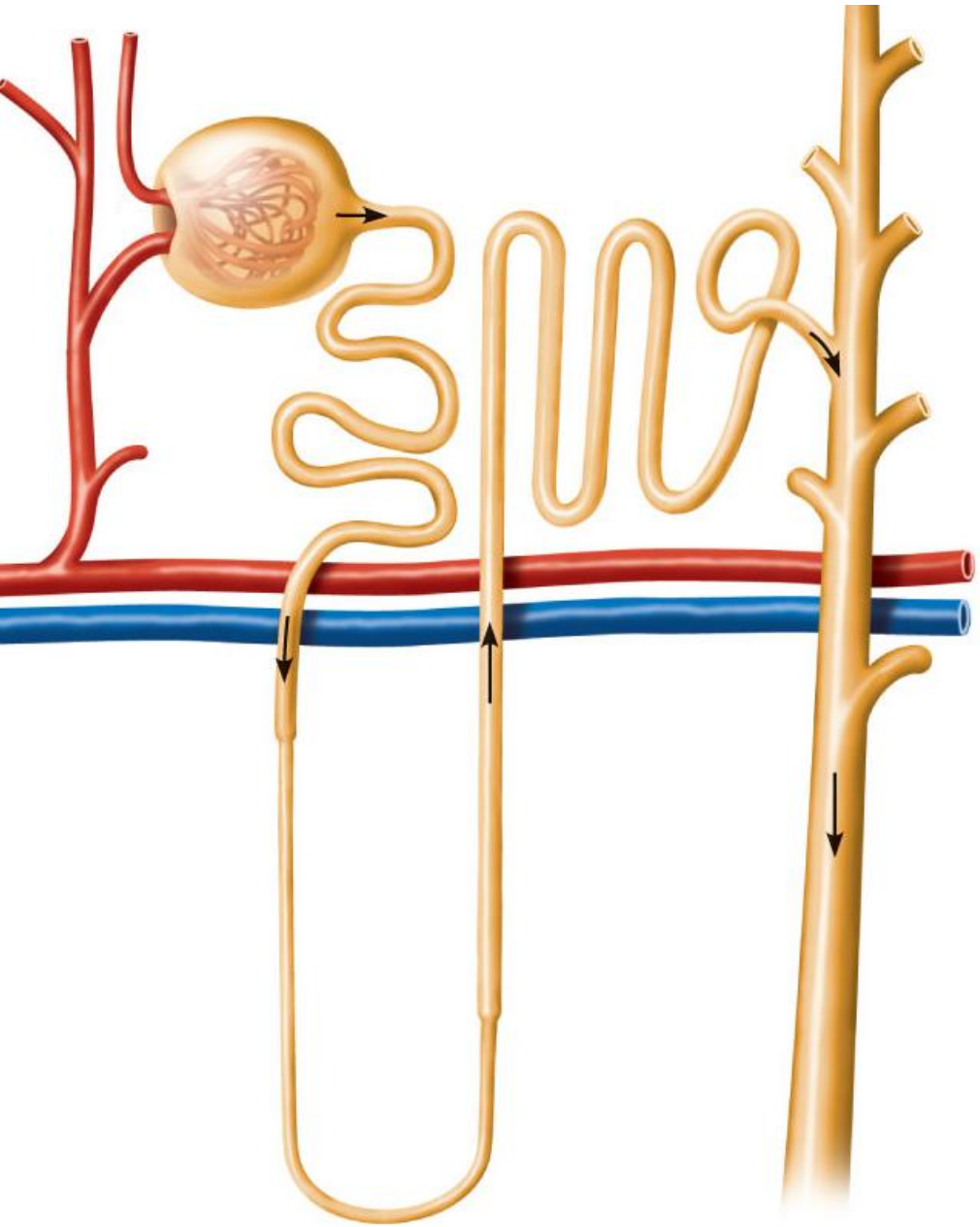


# Aldosterone

- Produced by the adrenal cortex.
- Produced when:
  - Plasma $Na^+$ is too low.
  - Plasma $K^+$ is too high.
  - Stimulated by angiotensin II.
- *What does it do?*





Aldosterone acts on the DCT & CD to increase the secretion of $K^+$ and the reabsorption of $Na^+$ and water.

# *How would excess aldosterone affect*

- Plasma sodium levels
- Plasma potassium levels
- Urine output
- Blood volume
- Blood pressure

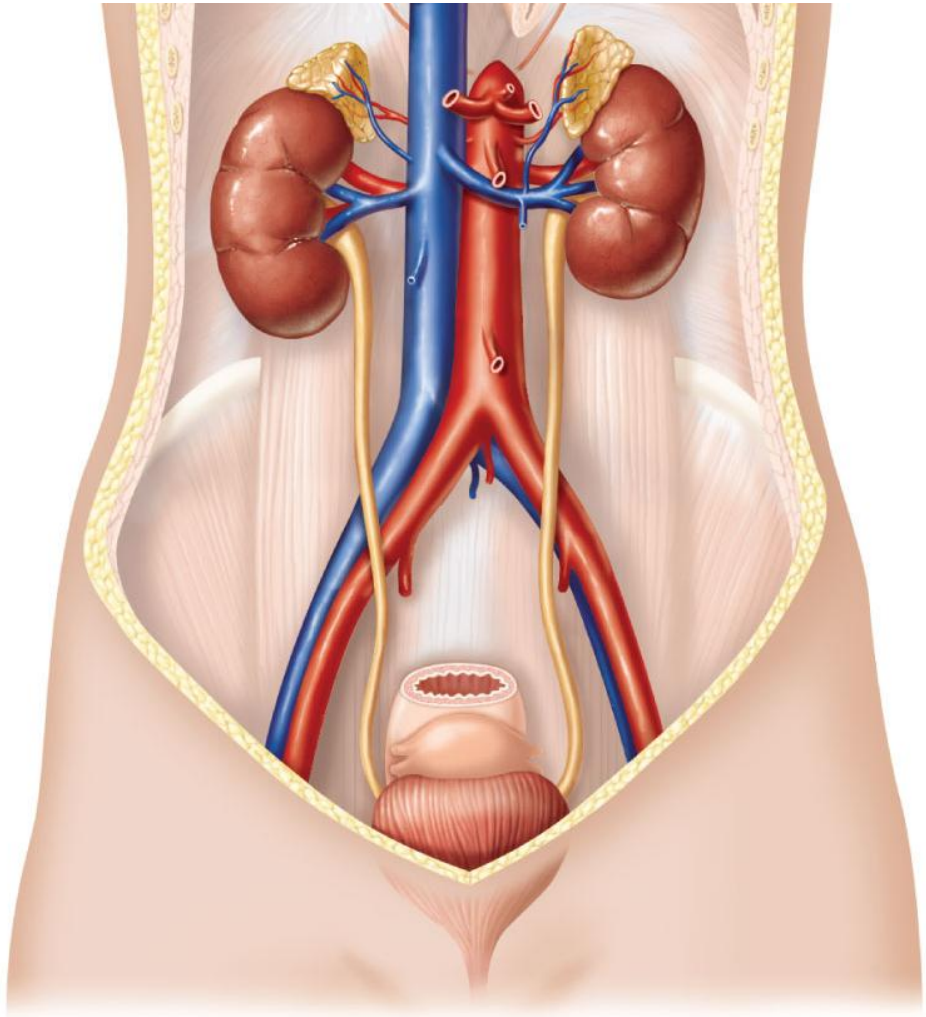
# Diuretics

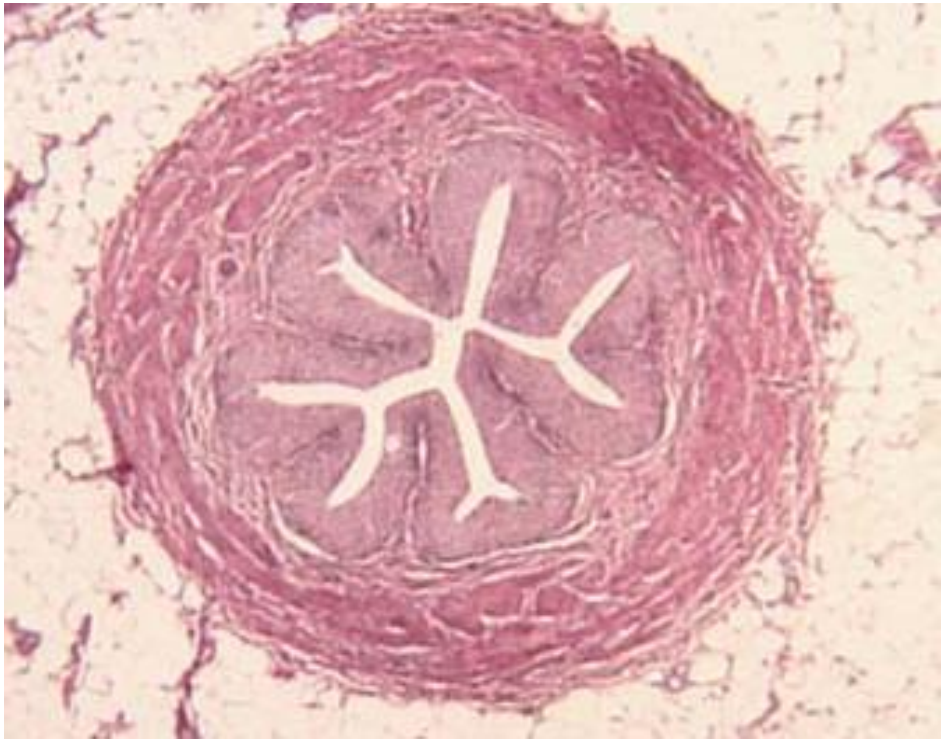
- Osmotic
  - Anything that increases filtrate osmolarity increases urine output.
- Caffeine
  - Inhibits renal sodium reabsorption.
- Alcohol
  - Inhibits ADH release.

# Urine

- Characteristics
  - Volume
  - pH of 4.5 - 8
  - Clear to yellow
  - Specific gravity of 1.001 – 1.035
- Components
  - 95% water
  - 5% solutes
    - Uric acid
    - Urea
    - Creatinine
    - Ions

# Ureters

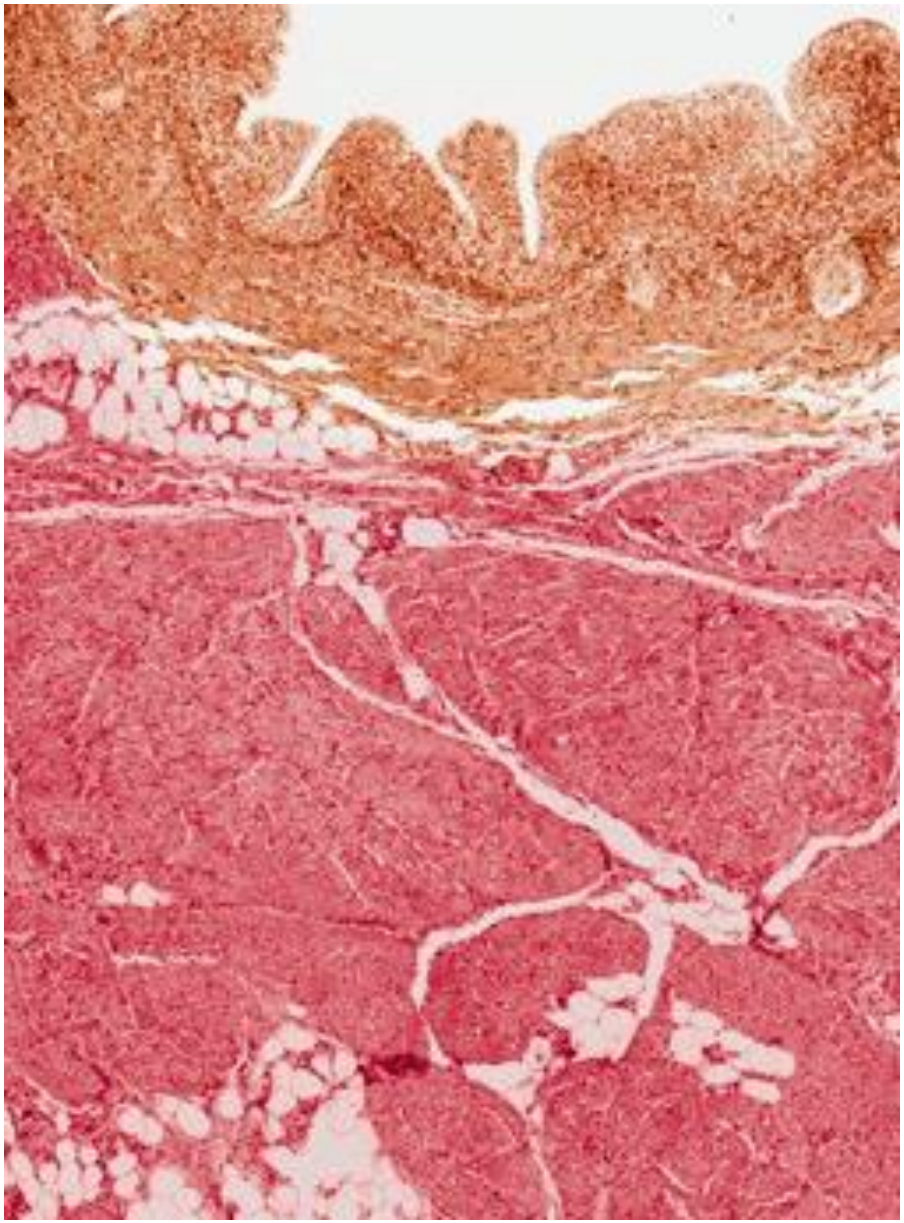


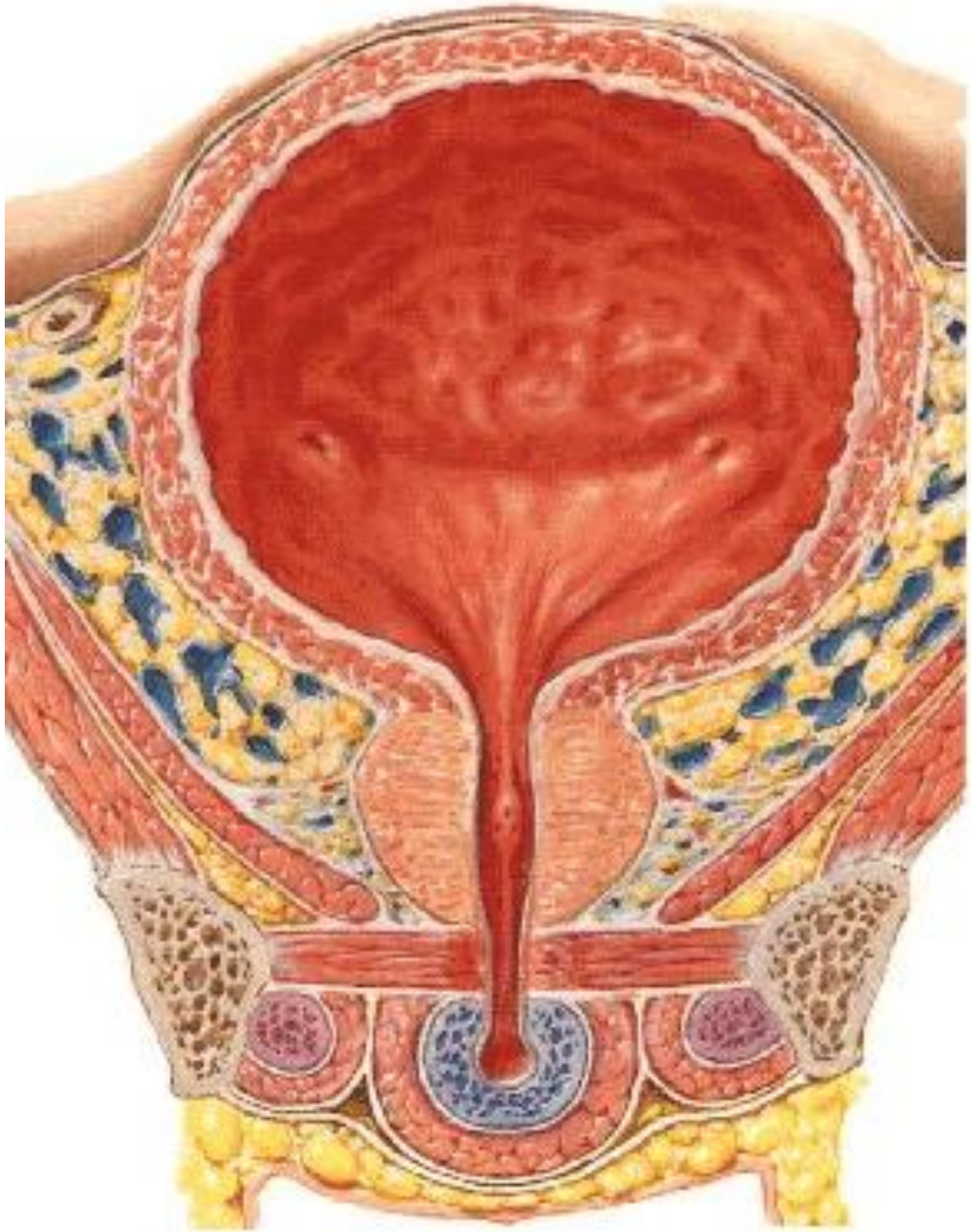


# Urinary Bladder

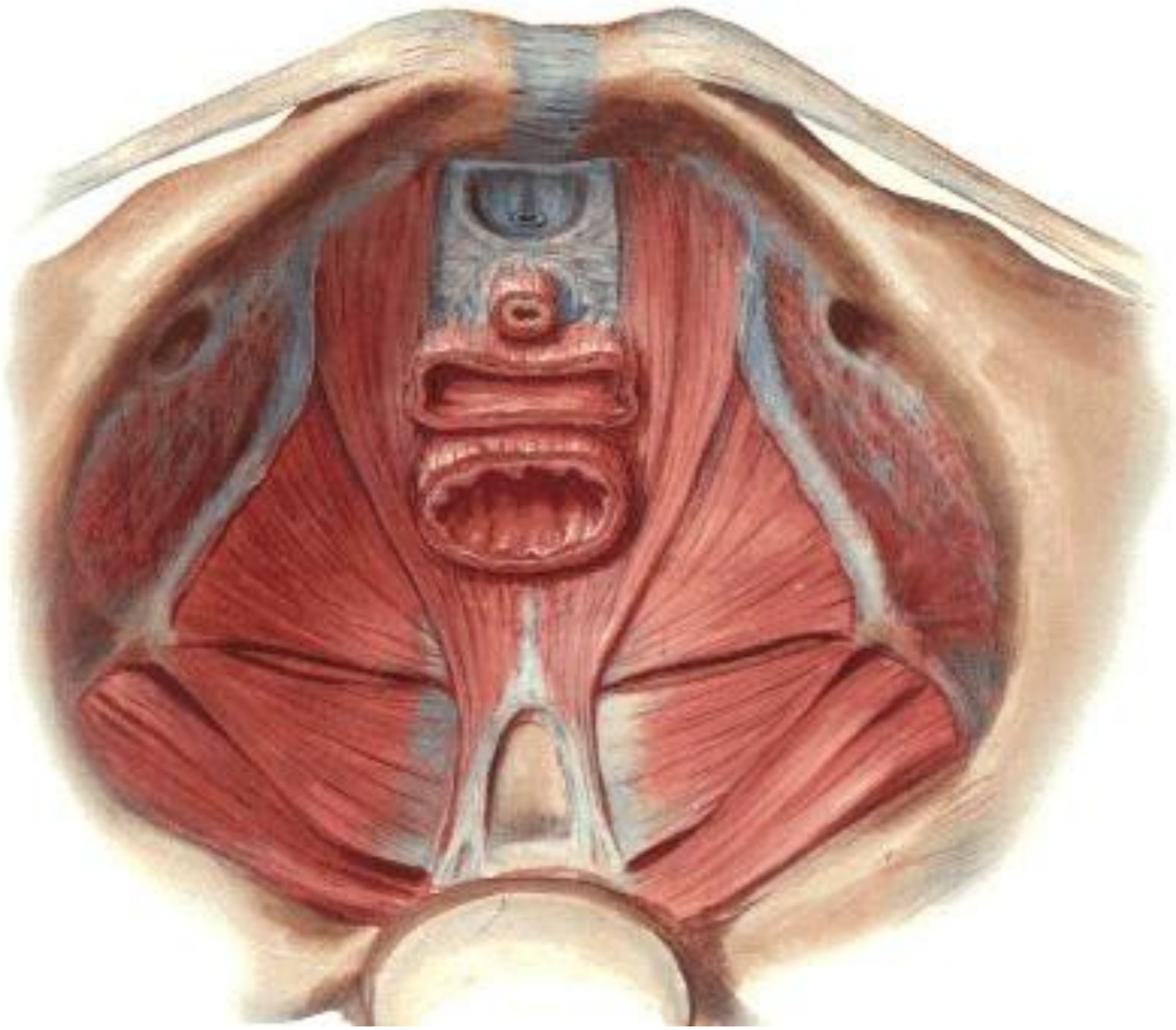
- Collapsible, muscular

- Function

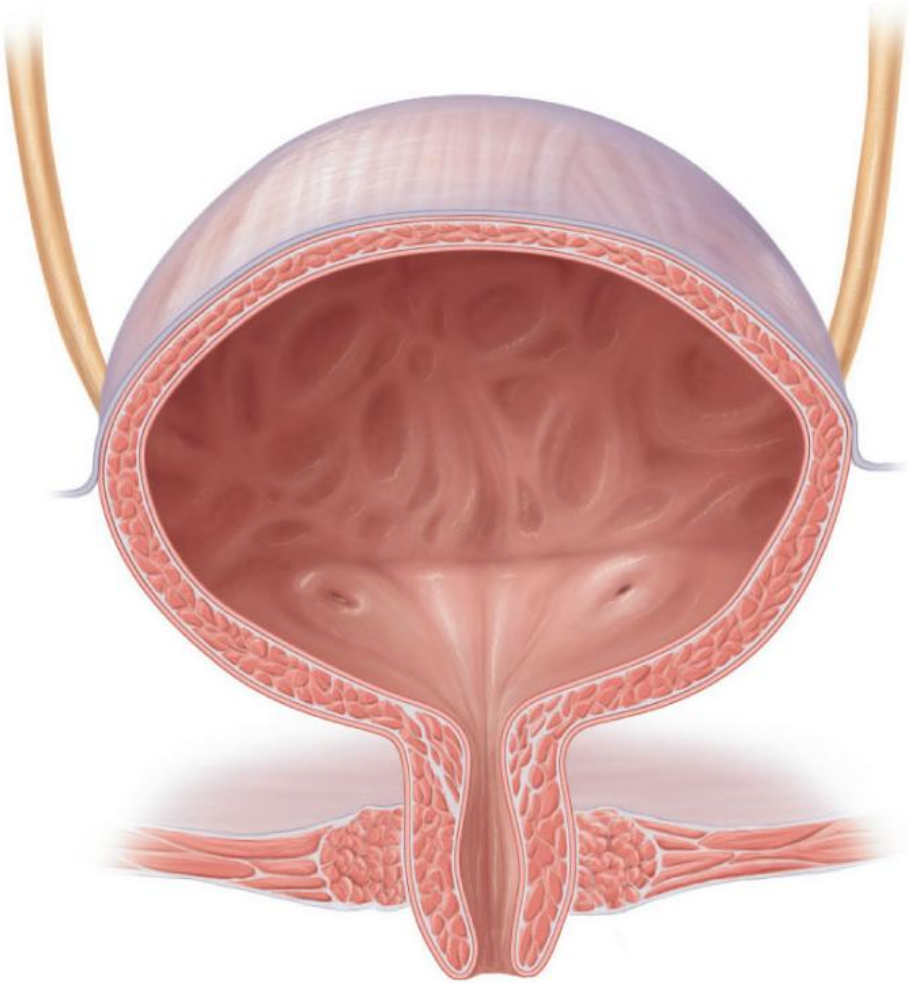


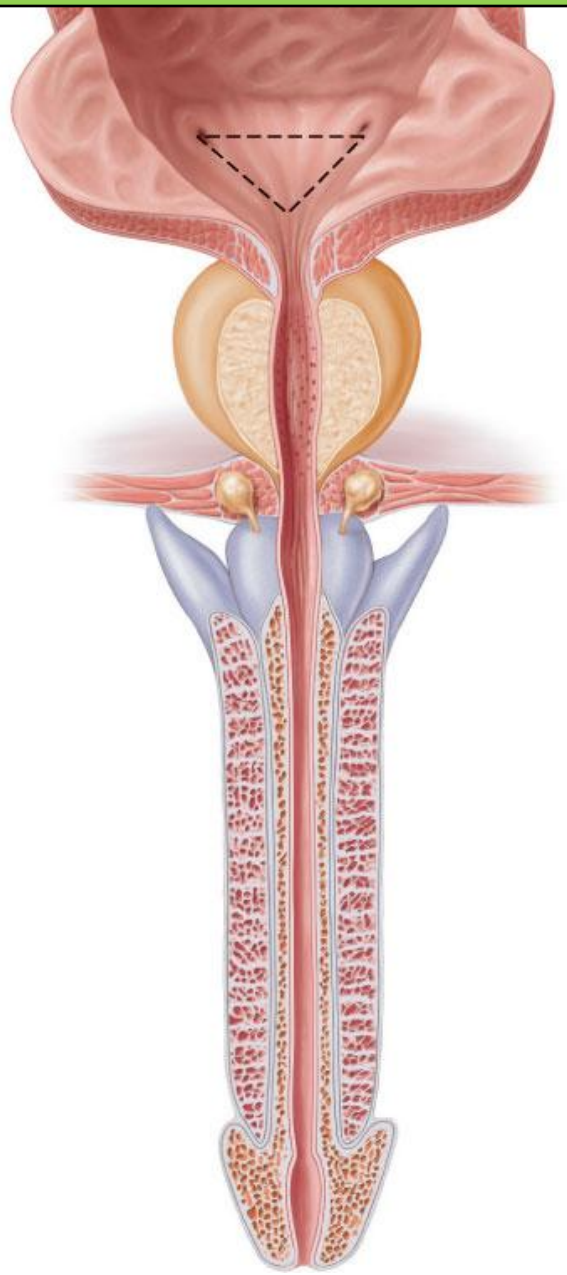


# Pelvic Diaphragm

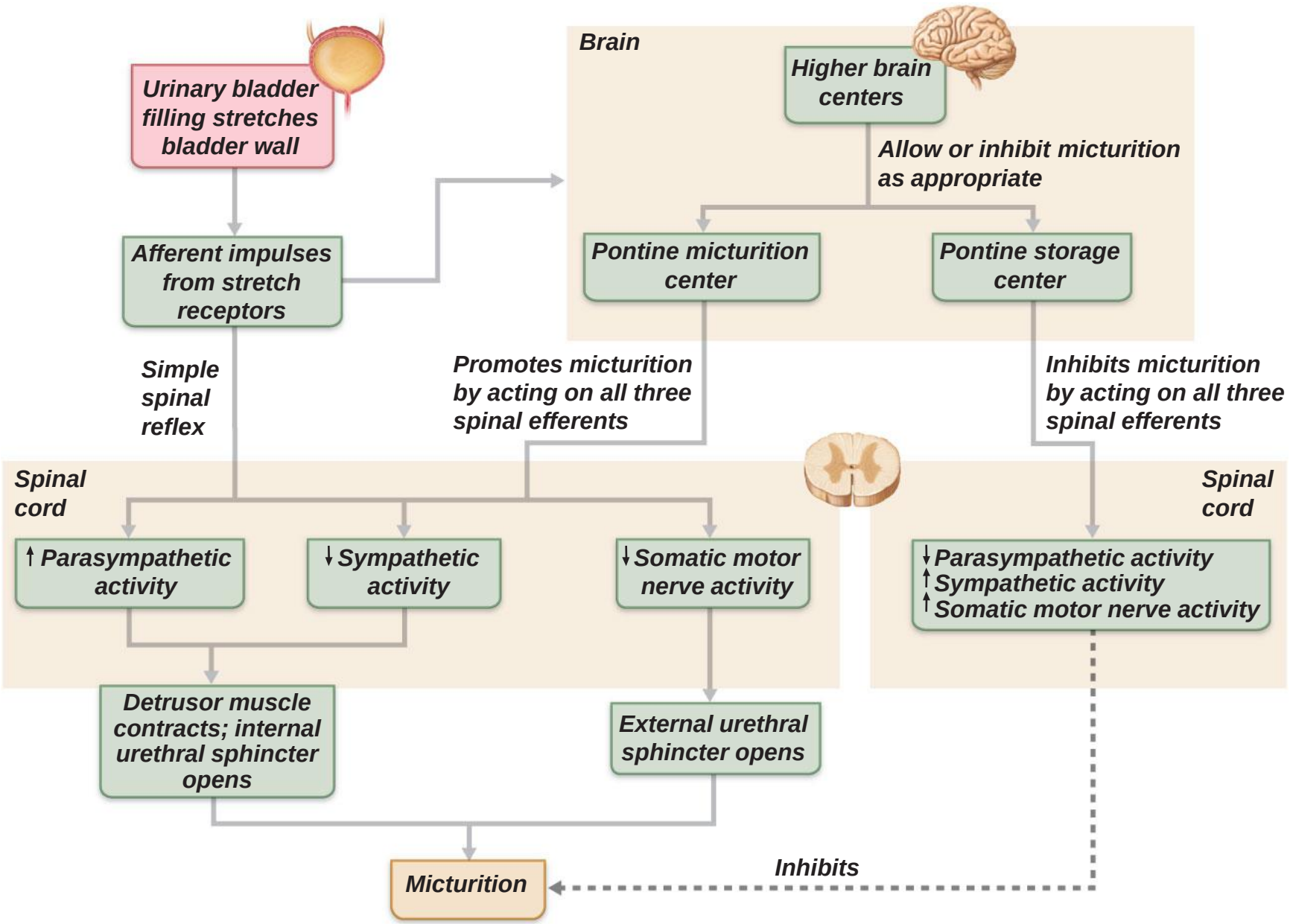


# Urethra





# Micturition


Urinary bladder filling stretches bladder wall
Afferent impulses from stretch receptors
Simple spinal reflex
Brain
Higher brain centers
Allow or inhibit micturition as appropriate
Pontine micturition center
Pontine storage center
Promotes micturition by acting on all three spinal efferents
Inhibits micturition by acting on all three spinal efferents
Spinal cord
↑ Parasympathetic activity
↓ Sympathetic activity
↓ Somatic motor nerve activity
Spinal cord
↓ Parasympathetic activity
↑ Sympathetic activity
↑ Somatic motor nerve activity
Detrusor muscle contracts; internal urethral sphincter opens
External urethral sphincter opens
Micturition
Inhibits